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Stender, P.J

UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

HYDROLOGIC CONDITION SURVEY

of the

SANTA FE MUNICIPAL WATERSHED

TESUQUE RANGER DISTRICT

SANTA FE NATIONAL FOREST

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ROCKY MOUNTAIN STATION

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HYDROLOGIC CONDITION SURVEY

of the

SANTA FE MUNICIPAL WATERSHED

Tesuque Ranger District
Santa Fe National Forest

Prepared by:

Peter J. Stander

March 18, 1965
Date

Approved:

R. E. Latimore
Forest Supervisor

March 22, 1965
Date

Submitted by:

Clarence F. Rich

March 19, 1965
Date

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HYDROLOGIC CONDITION SURVEY

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SANTA FE MUNICIPAL WATERSHED

The Watershed

General Description

The major drainage within the Santa Fe Municipal Watershed is the upper portion of the Santa Fe River. This river is part of the Rio Grande System. It lies to the east and northeast of Santa Fe in the Santa Fe National Forest. The headwaters lie in the Sangre de Cristo Mountains. The National Forest Boundary forms the lower boundary of the Watershed described in this report.

The Watershed contains 26.28 square miles or 16,819 gross acres of which 15,391 are National Forest, 1,428 are patented land. The gross acreage is that area which is within the Watershed and bounded on the West by the National Forest Boundary.

The Public Service Company owns and operates three reservoirs in Santa Fe Canyon. The three reservoirs are used entirely for supplying water to Santa Fe and the surrounding area.

Reservoir	Spillway Elevation	Total Capacity	Surface Acres	Length of Stream Above Res.
Two Mile	7,339	406 Ac.ft.	20	12.4 Miles
Nichols	7,485	796 Ac.ft.	25	11.1 Miles
McClure	7,885	2,908 Ac.ft.	80	8.3 Miles

Watershed Features

The Santa Fe River is a perennial stream. The flow is controlled and strongly influenced by the three reservoirs. The rest of the drainages in the Watershed are intermittent.

The stream pattern is dendritic. The Santa Fe Watershed is long and narrow with fairly steep slopes on either side of the Canyon. There is one main 4th Order stream (the Santa Fe River) that runs almost the entire length of the Watershed. Into this feed many first and second order streams from the mountainsides of the Canyon.

The elevation ranges from 7,340' just below Two Mile Reservoir to 12,409 at the top of Lake Peak. The elevation of Santa Fe Lake, the beginning of the Santa Fe River, is 11,590 feet. There is a difference of 4,250 feet in 12.35 miles of stream length. The average slope of the River

is approximately 344 feet per mile or 6.53 percent. Slopes on 65 percent of the area exceed 40 percent.

The soils are forming from parent material derived from the weathering of granite, gneiss, and schist of the Pre-Cambrian Age. These materials have been altered by glaciers at the higher elevations and by water in the bottomlands. Most of the soils are forming in the upland position, but narrow alluvial stringers occur throughout the Watershed.

Soil depths vary from 10 to 25 inches in the Pinon-Juniper, Ponderosa pine, and mixed conifer zones with textures ranging from loams to sandy loams. The profiles are usually very stony and gravelly with extensive areas of protruding bedrock and extremely rocky soils occurring throughout. These granite soils have moderate to moderately rapid infiltration rates. Water storage capacities are rated moderate because of their stoniness and soil depth limitations.

Moderately deep (24 to 36 inches) stony soils with loam and sandy loam textures occur in the spruce zone and above timberline. These are podzolized soils that have very stony gravelly profiles that usually have accumulations of iron in their subsoils. Because of the large amounts of rock material and high precipitation, these soils are very high water producers. The soils of this area are generally highly permeable. Most of the water, therefore, moves underground and emerges as seeps and springs. Peat bogs and intermittent lakes are common.

Vegetation

Because there is such a range in elevation, there are many major cover types. Near the top of the Watershed there are alpine grasslands and spruce - fir - aspen. Further down the drainage there is mixed conifer and some oakbrush. The major cover type from McClure Reservoir to Two Mile Reservoir is oakbrush, pine, and woodland. The woodland is restricted mainly to the south facing slopes. There is very little grassland and therefore, little grazing value in the Watershed. The bottomland has some cottonwoods and willows along the stream.

Factors for Special Consideration

The Watershed is a high water producing area especially in the upper portions. It is the main source of domestic water for the City of Santa Fe which is located at the mouth of the Watershed.

Besides the City of Santa Fe, other high values include the three public service reservoirs located in Santa Fe Canyon.

Prior to 1932, when the Watershed was formally closed by the Secretary of Agriculture, there had been heavy use by the residents of Santa Fe. Vegetation had been depleted by logging and over-grazing. Since 1932, the Watershed has been recovering.

Other factors to be considered are listed below by Watershed Management units:

WMU-1

1. This unit is made up of shallow coarse textured granitic soils that are easily eroded.

2. Vegetation and litter cover is very sparce. Run-off from high intensity storms is rapid because the water is not slowed down and absorbed by the cover.

WMU-2

1. Soils in Sub-unit 2A are rated in hydrologic soil Group C. Soils in Sub-unit 2B have a rating of High C because of the high percentage of soils in hydrologic soil Group B.

2. Much of this unit has stands of dog-hair Ponderosa pine.

3. On the more gentle slopes and especially under the dog-hair Ponderosa pine the litter has not been washed away, but rather has been able to build up. The steeper slopes have little or no litter cover.

4. Rapid surface runoff and erosion is controlled on much of the area.

WMU-3

1. This unit has a high percentage of rock outcrop especially in Sub-unit 3B and rockslides in Sub-unit 3A.

2. There is very little litter and vegetative cover because of the steep slopes and shallow soils. The main vegetation is oakbrush.

3. Run-off is very rapid because of the large amount of rock outcrop. Rockslides in Sub-unit 3A aid in the yield of high quality water.

WMU-4

1. This unit is made up of rock outcrops, rockslides and soils in

hydrologic soil Group B.

2. Overstory vegetative cover is good, but because of steep slopes, the litter cover has not built up except behind downed logs and some understory vegetation.

3. There is rapid surface runoff from high intensity storms; however, because of the soil depth, there is a fairly high water holding capacity in the soil profile.

WMU-5

1. Soils in this unit are similar to soils in WMU-4. Seventy-five to eighty percent of the unit is made up of soils in hydrologic soil Group B with the remainder of the unit consisting of rock outcrops and rockslides.

2. Generally speaking, slopes are steep with the exception of the canyon bottom around Santa Fe Lake.

3. Overstory vegetation (spruce-fir-aspen) is very good and litter cover is good.

4. This unit probably yields more water per unit area than any other unit on the Watershed; average annual precipitation is probably about 30 inches.

5. WMU-5 has a west aspect, and WMU-5B has an east aspect.

6. Precipitation in the form of snow is probably removed from the Santa Fe Ski Basin and from WMU-6 and deposited in WMU-5 in the canyon bottom.

WMU-6

1. About 70 percent of this unit is made up of rock outcrop and rock slides.

2. Vegetative cover consists of stunted trees(krummholz) and various alpine plants. Vegetative cover is sparce because of the high percentage of rock.

3. Much of the snow is probably blown off of this unit because it is exposed to high winds.

4. A cornice often forms in this unit under the upper poma lift terminal.

5. This unit has a south and east aspect.

WMU-7

1. Soils in Sub-unit 7A are alluvial and colluvial soils in hydrologic soil Group C. Soils in Sub-unit 7B are alluvial and colluvial

soils with some peat bogs. These are also in hydrologic soil Group C.

2. Both overstory and understory vegetation are very good. This unit has made excellent recovery since the Watershed was closed in 1926.

3. There is a road from the mouth of the canyon to Elk Cabin (P.I. #6)

4. The three reservoirs are located in Sub-unit 7A.

5. The canyon bottom is very narrow. Along much of the stream length, there is dense vegetative cover consisting of willow, alder, aspen, Ponderosa pine, and mixed conifer.

Recommendations

While the Watershed is closed, the following recommendations are made for improving and predicting water yield.

Streamflow Forecasting

The relationship between snow accumulation and runoff (April 1 to July 1) has been determined. (See section on Streamflow Forecasting). Of the 15 years of record, only two points fall within the + or - 10 percent margins.

Additional information is needed to refine this prediction line.

Snow courses on or near the Watershed are listed below:

Snow Course	Elevation	Period of Record
Elk Cabin	8,250	1948 - 64
Aspen Grove	9,100	1939 - 64
Big Tesuque	10,000	1942 - 64
Rio en Medio	10,400	1950 - 64

Elk Cabin is on the Watershed and Big Tesuque and Aspen Grove are located just north of the Watershed.

The amount of soil moisture is a very important factor affecting the snow melt run-off. A soil moisture station could be set up on the Watershed. There are soil moisture stations located at Big Tesuque and Rio en Medio which might be useful for this Watershed.

Precipitation data for April 1 to July 1 from the Tesuque weather stations could be used to refine the prediction line.

The present U.S.G.S. gaging station has been located below McClure reservoir since 1947. The Public Service Company operates two Parshall flumes above

McClure. There is a small flume for normal flows and a large flume for flood flows. These flumes could be used to give records of natural streamflow. i.e. not altered by a reservoir.

It is recommended that this proposal be coordinated with the Public Service Company and the Soil Conservation Service.

It may be possible to predict snowmelt run-off with present hydrologic information; however, the U.S.G.S. feels that additional data is needed for accurate forecasts..

"Before reliable forecasts of flow can be made, an adequate program of collection of the additional hydrologic data must be set up, although preliminary tests of the adequacy of present methods of forecasting can be made with present data. The data needed for accurate forecasting could be provided by installing two recording precipitation gages of the storage type at altitudes of about 9,500 and 10,500 feet and converting the gages at Elk Cabin and Santa Fe Lake to gages of the same type. All gages should be read regularly at monthly intervals. Observations of the depth and water content of the snowpack at selected locations representative of several altitudes should be made during the spring. A gaging station, constructed to permit year-around operation, should be established on the Santa Fe River just above the backwater of McClure reservoir. Similar gaging stations should be installed on the Santa Fe River below Santa Fe Lake at an altitude of about 11,000 feet, above Elk Cabin at about 9,000 feet, and below Two-mile reservoir at about 7,300 feet in order to determine the proportion of run-off from different altitudes. Soil moisture and water level records also should be collected."[1/]

If this recommendation by the U.S.G.S. would be followed, it would mean setting up four new precipitation stations, four new stream gaging station, and a number of snow courses. This would probably give the most accurate information for predicting streamflow since it would break the Watershed into different elevational zones in which run-off could be predicted; however, such an undertaking would be very costly for both the initial construction, and for reading and maintenance of the instruments. Construction, reading, and maintenance of instruments near the top of the Watershed would be especially costly because there is no access road past Elk Cabin (P.I. #6). Such instrumentation should be a cooperative venture among the U. S. Forest Service, Public Service Company, U. S. Geological Survey, the Soil Conservation Service and possibly the State Engineer.

Water Yield Improvement

A. The top terminal of the poma lift on the Santa Fe Ski Basin has too much snow. According to Dr. Martinelli, a careful study should be made to determine where the excess snow is coming from. One of his

recommendations to solve this problem is to remove the thin fringe of trees behind the bull wheel so that the snow can be swept from the terminal into Santa Fe Canyon. He points out that experimenting will be necessary to solve the problem. He also states that this will cause cornicing on the lee side (in Santa Fe Canyon).

Removal of any trees at the upper terminal should proceed very slowly. By removing trees, there may be a funneling effect, and the winds will increase in velocity. This could cause a serious blowdown problem in the standing timber. It may be desirable to remove only one or two trees every year until the desired effect is achieved.

B. It is estimated that 350 acre feet of water per year is lost by evaporation from the three reservoirs in Santa Fe Canyon. Studies on Elephant Butte Reservoir, New Mexico and on Pactola Reservoir near Rapid City, South Dakota may give valuable information on the amount and cost of evaporation suppression. Completion of these reports may give a basis for determining whether to use monomolecular films on the reservoirs in Santa Fe Canyon. The cost of evaporation suppression may range from $20 to $35 per acre foot saved once the technique is perfected.

Watershed Restoration

The Corps of Engineers is considering a rechannalization project in the Watershed. The purpose of the project is to reduce flood hazard and sedimentation. If this project is not done, then the Soil Conservation Service may study the Watershed for a PL 566 project with the same objectives in mind. In either case, the Forest Service should be in close contact with both agencies.

If and when the Watershed is opened to multiple use, the following factors should be considered for maintaining water quality and improving water yield:

Watershed

The following recommendations should be carried out only after research has come up with definite conclusions about increasing water yields by vegetative manipulation. If these recommendations appear feasible, a specific program should be set up with guidelines from Watershed Research and Administrative Studies.

A. Clear-cut timber in blocks, strips, etc. which ever would give the best results. This would probably be done only in the spruce-fir (WMU-5) where clear-cutting is an accepted silvicultural practice. Because these soils may erode easily on steep slopes, it is recommended that all cutting be done on slopes less than 25 percent. Another approach would be to cut the timber and leave it in place. This would require treatment if there was an insect build-up.

B. Thin dog-hair stands of Ponderosa pine in WMU #2. This will allow more precipitation to reach the ground and will reduce transpiration. Whether this will appreciably increase streamflow is not known, but it is being investigated by research and administration. Again, it is recommended that this work be done on the more gentle slopes because of the erosion hazard.

C. Reduce streamside vegetation consistent with fish habitat needs. Much water is lost by transpiration from these phreatophytes. If the canyon is opened up to recreation and fishing, some of this vegetation should be removed to provide access to the stream bank.

Timber

If it is practical and desirable to cut trees for water yield improvement, a volume and quality cruise should be made in WMU #5 where the cutting would be done.

Recreation

If this canyon is opened up to recreation use, all recreation facilities should be constructed before allowing public use.

A. Any toilets constructed within the Watershed should be clearly visible and well signed, away from the drainage bottom, and concrete lined.

B. Recreation areas, especially those near live water, should be well signed to explain that the area is a municipal Watershed, that garbage cans and toilets should be used and that open fires are not

permitted under any condition.

C. No overnight camping should be allowed because of the danger of fire, sanitation, and lack of suitable camping areas.

D. A full time seasonal recreation-fire guard would be needed to patrol the watershed and to control smoking only at designated picnic sites.

E. Hunting might be permitted under strict control.

Engineering

At this time the only access into Santa Fe Canyon is by way of the narrow Canyon Road. This road becomes a one lane dirt road within the National Forest boundary. In many places it does not have adequate drainage. If the watershed is to be opened to public use, another access route will have to be provided. Two road locations are shown on the approved transportation plan of the Tesuque District. They are:

1. By way of the Black Canyon road from the north and continuing on toward the Pecos River. This road will be a high standard forest highway and would cross the top of the watershed.

2. By way of Arroyo Hondo from the south. This road would be a low standard forest development road and would tie into the Black Canyon road near the top of the watershed.

A. Make a feasibility study of the two suggested road locations as well as any others that may provide access to the watershed. After a route has been flagged, a multiple use coordination survey should be prepared. The following should be considered:

1. The road should be kept at a low grade.
2. The road must be kept out of channel bottoms.
3. The road must be well drained to prevent erosion.

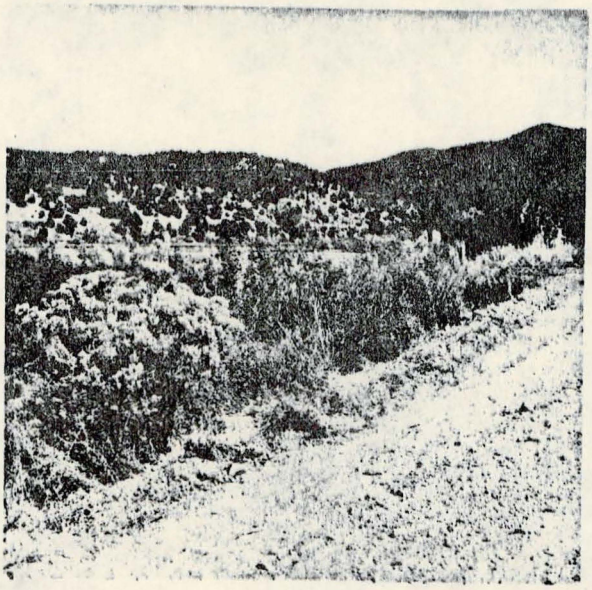
B. The present road has culverts that are silted in and have become ineffective. These culverts should be cleaned out. Along other sections of the road, there is inadequate drainage. These sections should have rolling dips put in. Some portions of this road are on Forest Service land while other portions are on Public Service owned land.

Range

No livestock grazing should be permitted because of the lack of suitable range and more importantly because of the danger of pollution.

WATERSHED MANAGEMENT UNIT DESCRIPTION

WATERSHED MANAGEMENT UNIT #1



Granite - C	P-J 40
Gneiss	Rock 35
Schist	

1

30-60	Sheet 25
	Rill

Physiography

This unit consists of shallow to very shallow (less than 20 inches deep) stony medium textured soils forming in parent material weathered residually from Precambrian granite gneiss and schist.

Soil depths range from 6-20 inches. Soils consist of about 6 inches of grayish brown stony loam surface soil which rests on about 12 inches of very stony loam substratum material that grades to bedrock.

Stone, cobble, and rock cover approximately 60 percent of the surface. The content of cobble and stone comprises about 30 percent of the surface soil and from 40 to 80 percent below. These soils are in hydrologic soil group C because they have a moderate infiltration rate and have a moderately rapid percolation rate.

Slopes vary from 30 to 60 percent and average about 50 percent. Protruding rock and rockslides make up about 10 percent of sub-unit 1-A and about 25 percent of sub-unit 1-B.

These soils have a moderate erodability index and a moderately high erosion hazard.

Water storage is moderately low

Forage potential is low.

Vegetation

Because the soils have a low water holding capacity, the vegetation is strongly influenced by aspect and soil depth. The main overstory vegetation is pinyon-juniper. The understory vegetation is very sparce especially on the shallow soils of the slopes. The overstory vegetation makes up approximately 35 percent of the ground cover density. Litter occurs directly under the overstory vegetation and is very shallow. The ground cover density of the interspace is about 10 percent on sub-unit 1-A and about 20 percent on sub-unit 1-B. The primary vegetation in the understory is blue grama.

Hydrologic Functions

During high intensity short duration storms, surface runoff is probably very high relative to the amount of precipitation because of the steep slopes, shallow soils, and limited ground cover.

There is probably not much runoff from this area during and after low intensity storms of the frontal or cyclonic type. Also the runoff is probably very low from snowmelt. Low runoff from these types of precipitation is the result of the high evaporation rate and the ability of the soil to take in small amounts of water. Evaporation from these soils is very high because there is so little litter and vegetative cover. Water production from this unit is very likely only 10 to 20 percent of the total annual precipitation.

Soil erosion is mainly sheet and rill erosion. When this type of soil has little or no litter or vegetative cover it erodes very easily in high intensity storms. The surface soil consists largely of gravel sized particles that are held in place only by a small amount of loamy soil. When this loam is eroded away, the larger particles also begin to move causing large quantities of soil and rock to flow down the steep slopes.

WATERSHED MANAGEMENT UNIT #2

Picture taken October 1964

Granite, Gneiss, & Schist

2B - High C
2A - C

PF.0 - 70
Rock - 10

2

30 - 70

Sheet - 20
Rill

Physiography

Sub-unit 2A consists of approximately:

20% rock outcrops and rock slides
55% hydrologic soil group C
25% hydrologic soil group B

Sub-unit 2B consists of approximately:

10% rock outcrop and rock slides
35% hydrologic soil group C
55% hydrologic soil group B.

The average hydrologic soil group rating is C for sub-unit 2A and high C for sub-unit 2B.

Soil Descriptions

Hydrologic Soil Group C consists of shallow (10 to 20 inches) dark colored, stony, medium textured soil. The surface soil consists of about 8 inches of grayish brown, stony loam. The subtratum consists of about 10 inches of brown, very gravelly loam that grades to granite, gneiss and schist bedrock. From 30 to 60 percent of the surface is covered with stone and cobble. The stone and cobble content ranges from 20 to 40 percent in the surface soils and from 30 to 80 percent in the lower horizons. The depth to bedrock varies from 18 to 36 inches. The infiltration rate is moderate and the percolation rate is moderately rapid. The water storage capacity is moderately low.

Hydrologic Soil Group B consists of shallow to moderately deep, well drained, moderately coarse textured soils. There is a one to three inch needle layer above a dark grayish brown gravelly sandy loam surface soil that extends to a depth of about 10 inches. Beneath this is about 6 inches of very gravelly loamy sand that rests on weakly weathered bedrock. From 10 to 25 percent of the surface is covered with stone and rock. The soil profile contains from 20 to 50 percent stone and cobble. Generally, the soil is gravelly throughout. Infiltration and percolation rates are moderately rapid, and water storage is moderate.

Slopes in WMU 2 range from 30 to 70 percent and average about 40 percent.

Vegetation

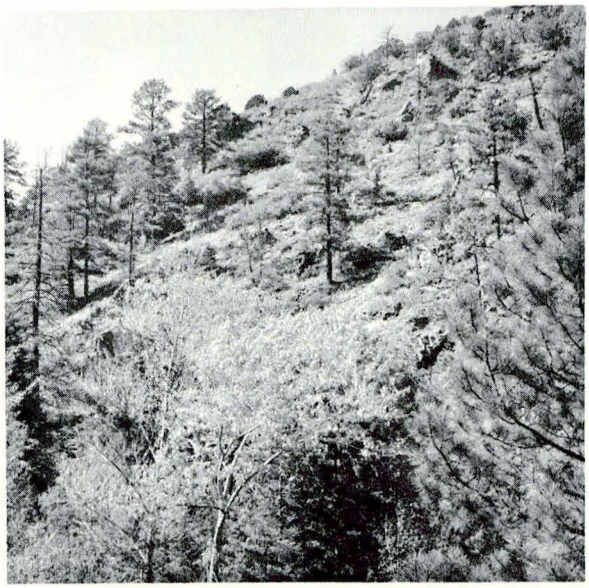
The overstory vegetation in this unit is primarily ponderosa pine. The crown cover density is approximately 50 percent. In some areas on both sub-units there are very dense dog-hair stands of ponderosa pine. There is no understory vegetation under these stands but there is a needle cast that is about 2 to 3 inches deep. On the more open stands of ponderosa pine there is gambel oak in the understory. Grass species include nodding brome, mountain muhly, and junegrass. The litter cover under the open stands is usually less than one inch deep. The ground cover density averages about 50 percent of the interspace while bare soil occupies about 25 percent of the interspace.

Total ground cover density is 75 percent for sub-unit 2A and 65 percent for sub-unit 2B.

Hydrologic Functions

Surface runoff is fairly well controlled on this watershed management unit by the litter cover. Litter cover has built up under the more dense stands of ponderosa pine and on the slopes that are not so steep that the litter cover is continually washed off. The hillsides with small amounts of understory vegetation and litter cover react in much the same way as WMU-1 does. On the steep barren hillsides, surface runoff is rapid and sheet erosion is very prevalent. However, most of the area has recovered from past overuse and is now in fairly good hydrologic condition.

WATERSHED MANAGEMENT UNIT #3



Picture taken October 1964

Granite, Gneiss, and Schist		Chapparral 30
High D		Rock 40
	3	
50 - 90		Sheet - 30
		Rill

Physiography

The soils in WMU3A are similar to the soils in hydrologic soil group C described in WMU.2. The component parts of this unit are:

1. 50 percent rock outcrop and rock slides (hydrologic soil group D)

2. 50 percent hydrologic soil group C. Slopes in this sub-unit range from 40-100 percent and average about 60 percent.

The soils in WMU3B are:

1. 60 percent rock outcrop (hydrologic soil group D)

2. 40 percent hydrologic soil group C. A description of this soil can be found in WMU-1.

Slopes in this sub-unit range from 50 to 100 percent and average about 65 percent.

Vegetation

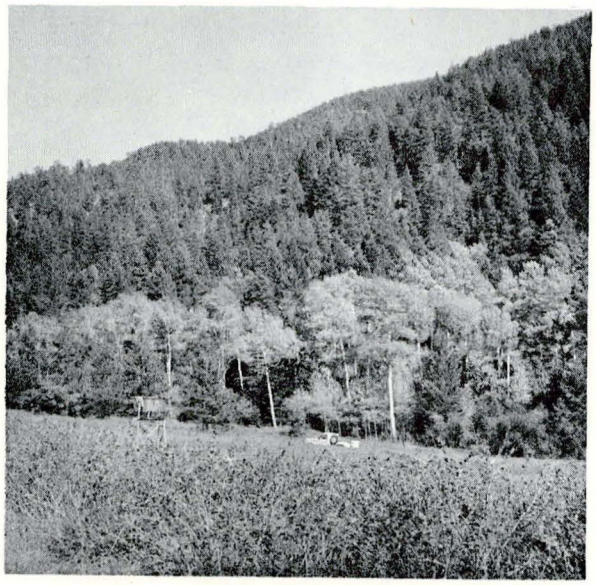
This watershed management unit has been broken out from the adjacent units because of the vegetation and steep slopes. The vegetation on most of the unit is gambel oak and a few other shrubs. Forbs and grasses are very limited because of the steep slopes and shallow soils. Litter cover has not developed because the leaves from these shrubs are easily washed away especially on the steep slopes. There are stringers of mixed conifer in the drainage bottoms where there is more available moisture.

Hydrologic Functions

Because of the extremely steep slopes, the low ground cover density, and the high percentage of rock cover, there is much surface runoff from high untensity storms. Erosive potential of the surface runoff is very great. However, because of the rock cover, actual erosion is reduced.

Sub-unit 3A contains several rock slides that probably contribute greatly to water yield. This unit has a north aspect and is in a fairly high precipitation zone. Evapotranspiration losses would be minimized on these rock slides.

WATERSHED MANAGEMENT UNIT #4



Granite, Gneiss, & Schist	M.C.	70
High C	Rock	10
4		
40 - 90	Sheet	20

Physiography

Sub-unit 4A consists of :

(1) 35 percent rock outcrops (hydrologic soil group D)

(2) 65 percent hydrologic soil group B.

Soil Descriptions

Hydrologic Soil Group B consists of deep, well to excessively drained, light colored, coarse to moderately coarse textured soils. It is characterized by 24 inches of light colored, gravelly sandy loam which grades to the very stony subsoil that is generally sandy loam. About 20 to 50 percent of the surface soil and about 60 to 90 percent of the subsoil consists of gravel and stone. Depth to bedrock is generally greater than 60 inches. Slopes vary from 45 to 80 percent and average 60 percent.

The erodibility index is low but the erosion hazard is high because of the steepness of the slopes.

Infiltration is moderately rapid and percolation is moderate. These soils have a moderate water holding capacity.

Other soils in hydrologic soil group B are discussed in WMU-6.

Sub-unit 4B consists of:

1. 30 percent rock outcrop (hydrologic soil group D)

2. 70 percent hydrologic soil group B.

Refer to WMU-2 for information about soils in hydrologic soil group B.

Slopes range from 30 to 80 percent and average about 45 percent.

Vegetation

The overstory vegetation on this unit consists of Douglas-fir, white fir, limber pine, Engelmann spruce and some ponderosa pine. The understory vegetation consists of oak, kinnikinnic and other shrubs. Forb and grass production is not great on this unit.

From observation it appears that litter is easily washed away on slopes greater than 50 to 60 percent. On these steep slopes the litter accumulates on the uphill side of shrubs and fallen logs. On slopes less than 50 to 60 percent the litter is not washed away. This observation was made only on the north aspect of this unit.

Hydrologic Functions

As just described, litter is easily moved on slopes greater than 50 to 60 percent. On these steep slopes there is very little ground cover in the interspace. During high intensity storms there is probably much soil movement in these areas that have steep slopes and little ground cover. The erosion process is probably very similar to the erosion process described in WMU-1. The particles of gravel on the surface are undermined until they become unstable and are washed away. In fact, when one walks across these bare areas much gravel is displaced and moved downhill until it comes to rest behind some vegetation or a fallen log.

Because of their depth, the soils in hydrologic soil group B can store considerable amounts of water during periods of snowmelt or periods of long duration low intensity storms of the frontal or cyclonic type.

Snowfall in this unit probably makes up about 40 percent of the annual precipitation or about 8 inches. Some of this snowfall will be intercepted by the overstory and some will be used to satisfy the soil moisture deficit. The remaining water will be available for runoff.

WATERSHED MANAGEMENT UNIT #5

Granite, Gneiss, & Schist		S.F.A.	90
Low B		Rock	5

5

30 - 60		None	5

Physiography

Sub-unit 5A consists of:

(1) 20 percent rock outcrop (hydrologic soil group D)

(2) 80 percent hydrologic soil group B.

Sub-unit 5B consists of:

(1) 25 percent rock outcrop (hydrologic soil group D.)

(2) 75 percent hydrologic soil group B.

Soil Descriptions

Hydrologic Soil Group B consists of moderately coarse textured soils forming in glacial till and valley fill derived from Precambrian granite, gneiss, and schist. These soils have about two inches of litter over about 7 inches of light brown loam to sandy loam surface soil. Beneath is about 16 inches of reddish brown stony sandy loam subsoil that gradually grades to the brown stony sandy loam substrata. Stone and gravel content varies from about 5 to 20 percent near the surface to about 30 to 60 percent below.

These soils are well drained but because of their depth they can hold considerable amounts of water. Infiltration and percolation are moderately rapid.

Slopes generally range from 30 to 60 percent on both sub-units; however, about 10% of the slopes are less than 30%. The slopes directly under the alpine zone (WMU-6) are very steep (80-90 percent).

Vegetation

The overstory vegetation on this unit is Engelmann spruce and white fir. The density of the overstory is about 80 percent on north facing slopes and about 70 percent on south facing slopes. The primary understory vegetation is huckleberry. Total ground cover density for this unit is estimated at 90 percent. This includes the overstory vegetation, understory vegetation and litter cover. The remaining 10 percent is made up of rock outcrop and bare soil.

Hydrologic Functions

This unit probably yields more water per unit area than any other unit on the watershed for two reasons:
(1) This unit is near the top of the watershed and therefore receives more precipitation than most of the other units.

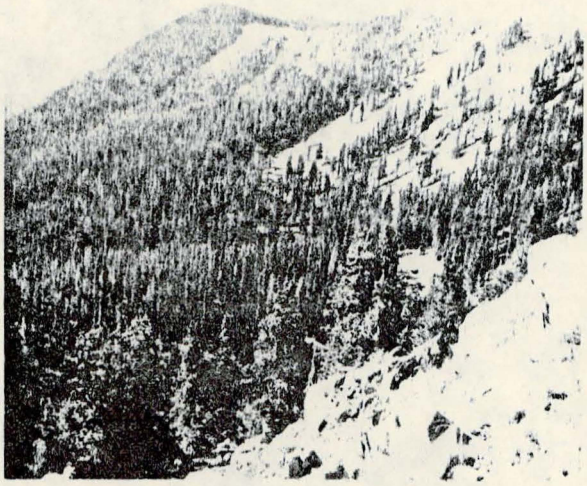
(2) Because of the trees the snow is not blown off as it is on WMU #6. In fact, snow from WMU #6 slides and blows from the alpine zone down to the spruce-fir zone. In some years much snow blows from the Santa Fe Ski Basin into Santa Fe canyon. When the wind blows from the west or north, the snow is carried across the alpine zone and is deposited in the basin near Santa Fe lake.

Once the snow has been deposited in this basin there is practically no way for it to be removed because of the steep slopes surrounding it on three sides.

Average annual precipitation is estimated to be from 25 to 30 inches. Of this amount probably 40 to 50 percent occurs as snowfall.

In the present condition there is no great erosion problem on this unit. There is some sheet erosion on the steeper slopes, but this is relatively minor.

WATERSHED MANAGEMENT UNIT #6



Granite, Gneiss, & Schist	Alpine 10
Low C	Rock 70

6

0-35	Sheet
	Rill 20

Physiography

This watershed management unit consists of:

(1) 45 percent rock outcrop (hydrologic soil group D.)
(2) 25 percent rockslides (hydrologic soil group D)
(3) 10 percent hydrologic soil group B as found in WMU #5.
(4) 20 percent hydrologic soil group B as described below.

Hydrologic Soil Group B consists of soils along the tops of mountains at elevations generally greater than 12,000 feet. These soils are moderately deep, stony, medium textured, very strongly acid alpine turf soils developing in glacial till derived from Precambrian granite, gneiss and schist. This soil is characterized by a mat of undecomposed organic matter about one inch thick over about 10 inches of very dark gray to black surface soil. Beneath this is about 14 inches of brown, very stony loam subsoil that grades to the very stony, sandy loam substrata which contains approximately 70 percent stone. The surface is covered with 10 to 30 percent stone and boulders.

Infiltration is moderately rapid and percolation is rapid. Water storage is moderate.

Slopes range from 0 to 35 percent and average about 20 percent.

This unit has generally a south aspect.

Vegetation

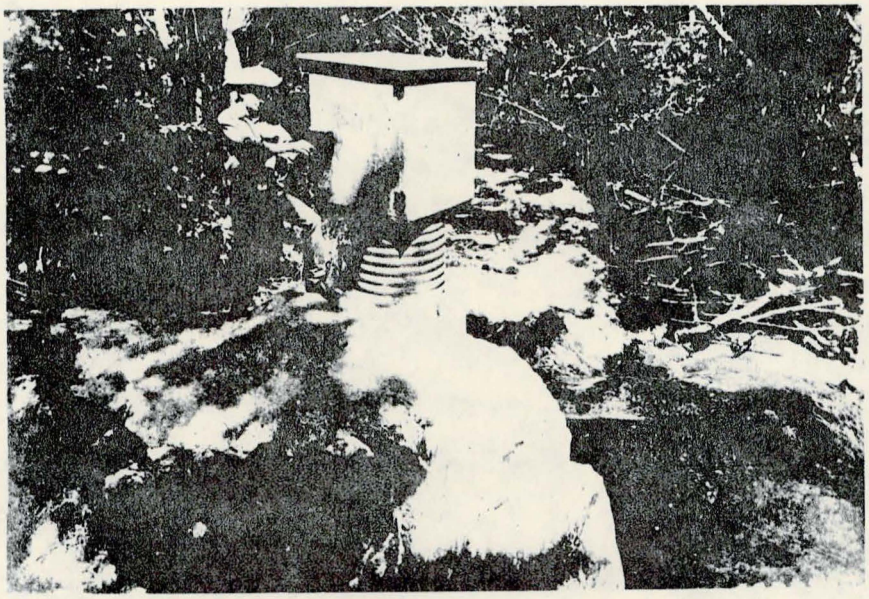
Scattered spruce and fir are found at the lower limits of the unit. Small pockets of stunted spruce were also found. Other vegetation consists of shrubby cinquefoil, bluegrass, and Kobresia. Vegetation is not very dense because of the high percentage of rock outcrop, rockslides and stones.

Hydrologic Functions

Average annual precipitation is probably 30 to 35 inches. Snowfall may account for as much as 60 percent of the annual precipitation. After the first snows have filled the depressions and surface irregularities have been eliminated, additional snow is very likely easily moved by winds. This snow would be moved into the Santa Fe Ski Basin or into the small basin near Santa Fe lake as described in the previous unit description.

Snowmelt from this area is probably very rapid because of the south exposure. Snowmelt is also increased because of the warm dry winds from the southwest. These winds are especially prevalent in the spring. If these winds carry moisture and are cooled near the dew point, moisture could be added by condensation to the snowpack; however, the net effect is believed to be a loss of moisture from evaporation.

WATERSHED MANAGEMENT UNIT #7



Granite, Gneiss, & Schist C	Willow Cottonwood 95 Alder

7

5 - 10	None - 5

Physiography

Sub-unit 7A consists of undifferentiated soils in the alluvial position that are forming in materials derived from granite, gneiss, and schist. These soils are medium to moderately coarse textured and contain lenses of gravel and cobble. Stones and boulders are often present on the surface. The surface soil ranges from silt to sandy loam. Depth ranges from 3 to 48 inches. The substratum is stratified sands, gravel and cobble.

Erodability and erosion hazard are high.

Infiltration and percolation rates are moderate. Water storage is moderately low.

Sub-unit 7B consists of:

(1) 20 percent rock outcrop (hydrologic soil group D.)
(2) 10 percent peat bogs (hydrologic soil group C) - Described below
(3) 20 percent hydrologic soil group B as described in WMU #5.
(4) 50 percent undifferentiated soils in the alluvial position (hydrologic soil group C.) - Described below

Soil Descriptions

Peat bogs are forming in basins and valleys in parent materials derived from acid igneous rocks. The soil varies from 40 to 60inches in depth. The texture varies from loam to silt loam. No stone or cobble are present but it may contain some fine gravel. This unit is poorly drained and has a fluctuating water table. This unit is characterized by a 3 to 10 inch peat layer over about 4 to 10 inches of black silt loam surface soil. Beneath is a gravelly substrata that ranges from gray to light yellowish brown to black or olive brown. These soils have a moderate erodability rating and a moderately low erosion hazard.

Infiltration is moderate and percolation is moderately low. Water storage is high.

Undifferentiated soils are dark colored medium textured and have variable depths. The surface soil is from 3 to 10 inches thick and has from sandy loam to loam textures.

The substratum is inconsistent in texture, depth, and stone content. The erodibility index and erosion hazard are high.

Infiltration and percolation are moderate. Water storage is moderately low because of the many shallow stony areas.

The slopes range from 5 to 10 percent but may be considerably higher on the side drainages.

Vegetation

Overstory vegetation in this unit consists of willow, alder, ponderosa pine, cottonwood, and mixed conifer above Elk Cabin. Understory vegetation consists of rabbit brush, bee weed, snake weed, lupine, yarrow and various other forbs. Grasses consist of blue grama, junegrass, blue grass, mountain muhly and others of lesser importance. Ground cover density is estimated to be 95 percent.

Hydrologic Functions

This area was broken out as a separate watershed management unit because of the hydrologic function; namely, that the Santa Fe River is located within this unit. Sub-unit 7A is made up, for the most part, of patented land. It is on this land that the Public Service Company has the three reservoirs. This sub-unit is accessible by way of a narrow road up the canyon bottom. This road dead-ends at Elk Cabin.

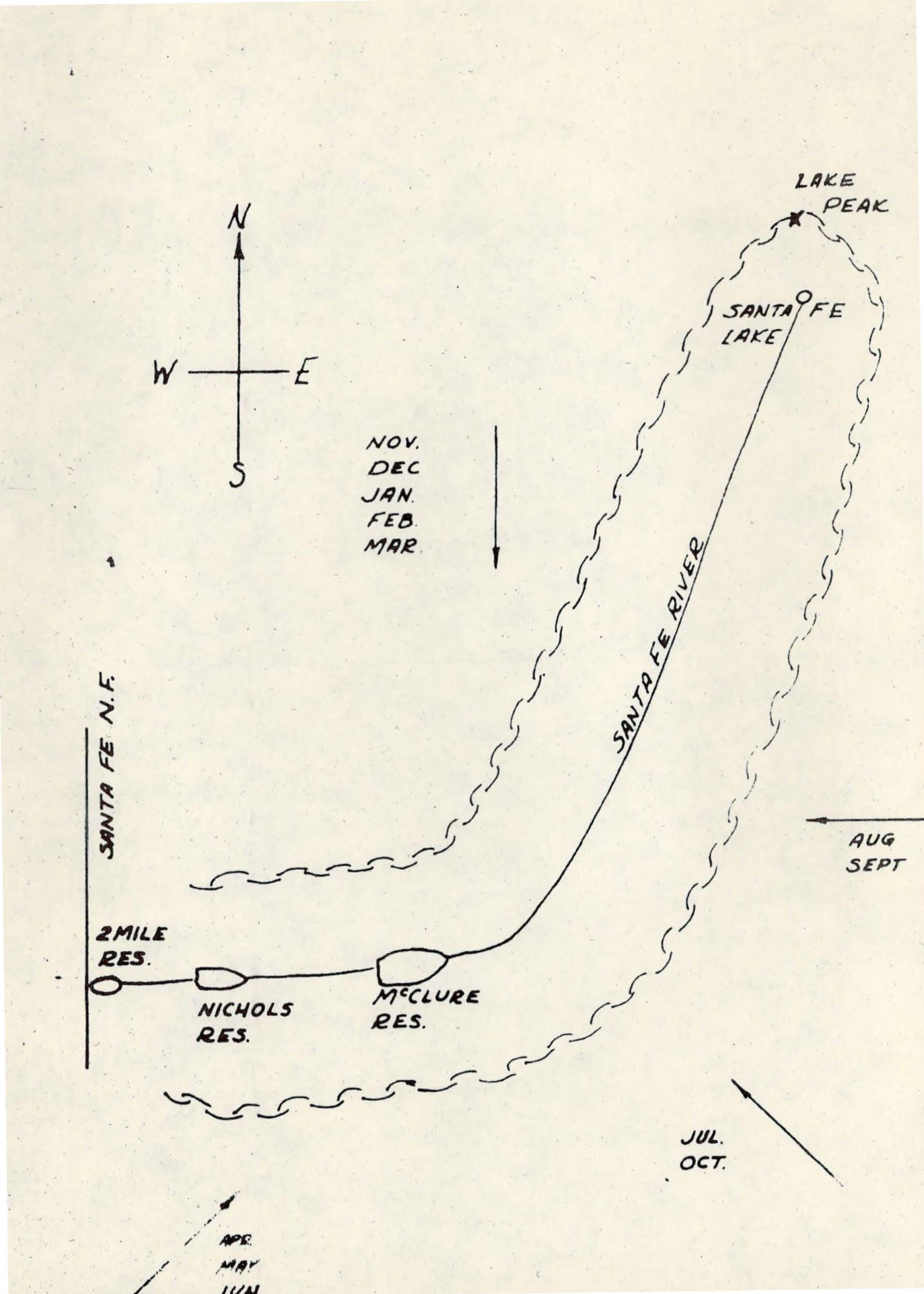
Dense vegetative growth is typical along sub-unit 7B. Santa Fe lake forms the upper end of this sub-unit.

(1) WMU	(2) Area Sq. Mi.	Acres	(3) % of Total	(4) ROCN	(5) Weighted ROCN (3) X (4)
1A	1.17	752	4.25	75	3.2
1B	4.14	2645	15.02	76	11.4
2A	5.13	3278	18.60	72	13.4
2B	3.02	1931	10.92	65	7.1
3A	.28	182	1.36	80	1.1
3B	.82	526	2.98	80	2.4
4A	3.06	1960	11.11	65	7.2
4B	2.58	1650	9.37	65	6.1
5A	3.10	1980	11.22	60	6.7
5B	2.76	1768	10.01	60	6.0
6	.12	80	0.44	82	0.4
7A, 7B	1.31	835	4.72	70	3.3
Total	27.49	17,587	100%		68.3

Climate

The following data was taken from the U. S. Weather Bureau publication Climatological Summary of Santa Fe. Although there is much variation between the climate of Santa Fe and the climate of the Santa Fe Watershed, the following information can be used as a rough guide for monthly and annual averages. The daily figures can be found in the Climatological Summary.

	Sunshine	Mean Temp.	Mean Max. Temp.	Mean Min. Temp.	Highest Temp.	Lowest Temp.	Wind Vel.	Wind Dir.
Jan.	72	29.2	39.6	18.9	76	-13	6.9	n
Feb.	69	33.2	43.7	22.8	75	-11	7.2	n
Mar.	71	39.7	51.2	28.1	82	-2	8.0	n
Apr.	73	47.3	59.5	35.0	84	11	8.2	sw
May	74	55.9	68.5	43.3	86	20	8.0	sw
Jun.	80	65.4	78.6	52.3	94	33	7.3	sw
Jul.	69	69.1	81.2	57.1	96	43	6.3	se
Aug.	71	67.7	79.6	56.1	97	40	5.9	e
Sept.	76	61.3	73.4	49.3	91	21	5.1	e
Oct.	80	50.6	62.5	38.7	85	13	6.5	se
Nov.	76	39.1	50.3	28.0	77	-11	6.7	n
Dec.	73	30.6	41.0	20.5	65	-13	6.8	n
Ann.	74	49.1	60.8	37.5	97	-13	7.0	se


LAKE PEAK
SANTA FE LAKE
N
W
E
S
NOV.
DEC
JAN.
FEB.
MAR.
SANTA FE RIVER
SANTA FE N.F.
AUG
SEPT
2 MILE RES.
NICHOLS RES.
McCLURE RES.
JUL.
OCT.
APR.
MAY
JUN

During the months of November, December, January, February, and March, the prevailing wind is from the north. Since these are the months of maximum snowfall, this wind direction will be an important factor in determining methods to increase snow accumulation such as cutting methods and placing snow fences. During the months of April, May, and June, the prevailing wind is from the southwest. These are also months that show the maximum amount of snowmelt. Undoubtably these winds that come from the plains are warmed and thereby aid in the melting of the snow. The winds for the remaining summer and fall months come from the east and southeast. These winds are probably not too effective in increasing evaporation since they must first cross the ridge on the south of the Watershed. These winds and their directions are for Santa Fe. In addition to these winds there probably are winds associated with convective currents of the mountains.

PRECIPITATION

Records

The station at Santa Fe (MSL 7045) has been maintained since 1853 with relatively few years of missing records. Records have been kept at Las Vegas since 1893, also with fairly consistent records. Since Santa Fe is at the mouth of the Watershed and Las Vegas is almost due east and also near the Watershed, the long term precipitation records have been used to determine variations in the precipitation regime. Two precipitation stations are presently being maintained by the Public Service Company. One station is at Elk Cabin and the other is near Santa Fe Lake. Records have been kept for the Elk Cabin station since 1947. The Santa Fe Lake Station has been read only in June and October since 1947. The records from this station are useful only for determining precipitation by water year and for an estimate of summer and winter precipitation. A precipitation station was maintained at 8400 feet elevation on the Watershed from 1910 to 1916 and from 1923 to 1928. These records can give some idea of the monthly distribution at that elevation. In general the records are to incomplete and too short to make valid conclusions as to the precipitation patterns on the Watershed. (See Appendix I)

Long Term Records

The Santa Fe records from 1853 to the present indicate that the mean precipitation is 14.46".[2] The Weather Bureau uses 13.72" as the average. The Las Vegas records indicate a mean precipitation of 18.06"[3] while the Weather Bureau considers 16.13" to be the mean.

From the plot of the long term records of these two stations, it can be noticed that there are corresponding peaks and troughs for the two stations; however the magnitude of these variations is different for each locality.

Frequency and Duration of Wet and Dry Years

The five year moving mean shows the patterns of wet and dry years. Santa Fe and Las Vegas both show similar trends as to frequency and duration of these periods. In general it can be said that approximately five years of above average precipitation is followed by five years of below average precipitation. Following is a table of wet and dry years for the two stations.

Long Term Variations

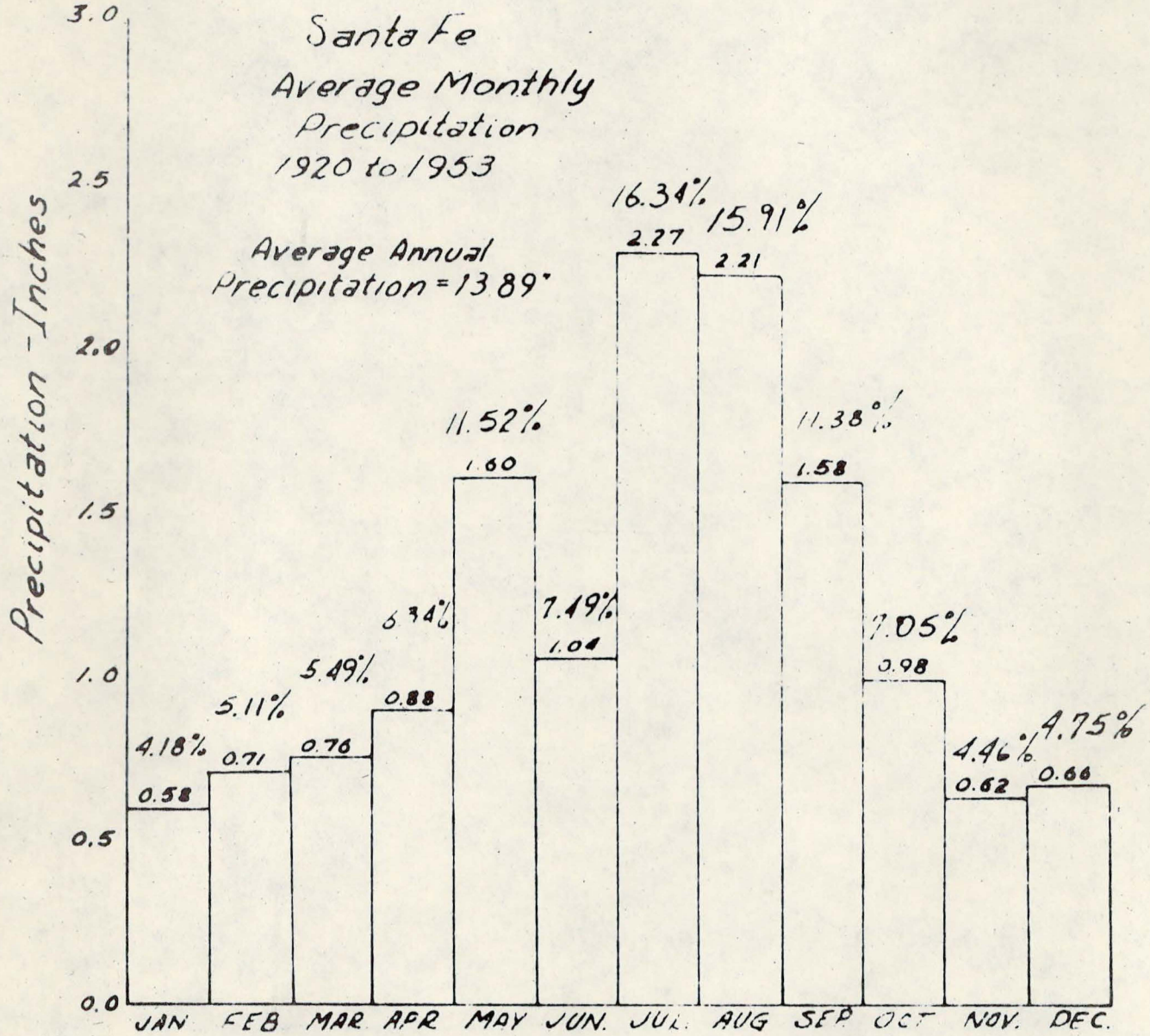
Frequency & Duration of Wet and Dry Years

From the Graph of Precipitation by Calendar Year

SANTA FE		LAS VEGAS	
DRY	WET	DRY	WET
1860, 61, 62, 63, 64	1865, 66, 67, 68		
869, 70, 71, 72, 73			
74, 75	1876, 77, 78, 79		
1880	1881, 82		
883, 84	1885		
886, 87, 88, 89			
90, 91, 92, 93, 94	1895, 96, 97, 98		1898, 99,
	99, 1100, 01		1900, 01
902, 03, 04, 05		1902, 03, 04, 05	1906, 07, 08, 09
06, 07	1908, 1909		10, 11
1910, 11, 12, 13, 14	1915, 16	1912, 13	1914
917, 18	1919	1915, 16, 17, 18,	1920, 21, 22, 23, 24
920	1921, 22, 23	19	
1924, 25, 26, 27, 28	1929, 30, 31, 32	1925, 26, 27, 28	
	33	29	1930, 31, 32, 33, 34, 35
934, 35, 36, 37,		1936, 37, 38,	
38, 39	1940, 41, 42, 43	39, 40	1941, 42, 43, 44,
	44, 45		45
946, 47, 47, 49		1946, 47, 48, 49	
50, 51, 52, 53		50, 51, 52, 53	
54, 55, 56, 57		54, 55, 56, 57	
58, 59, 60		58, 59, 60	

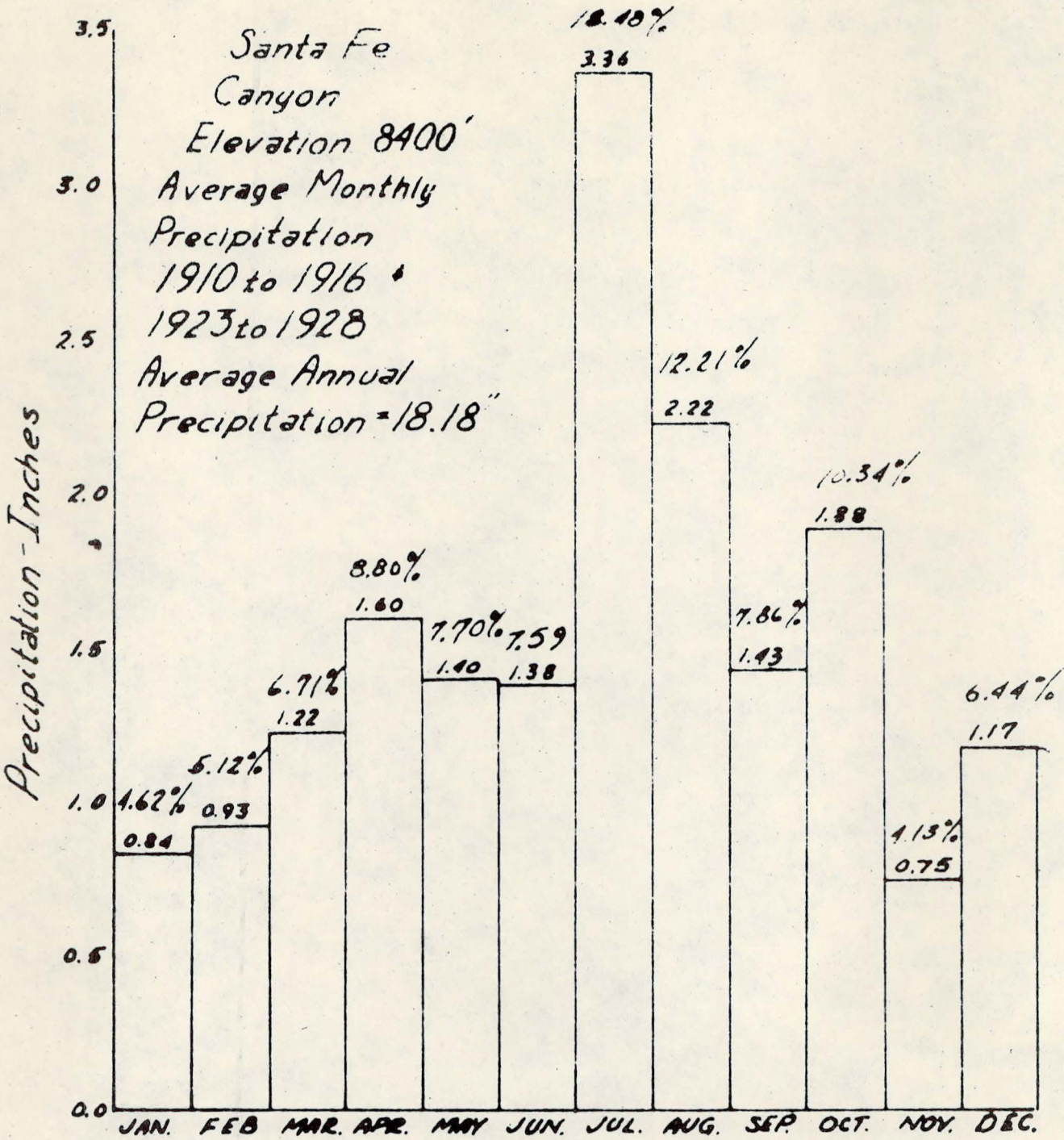
Monthly Averages

The following three bar graphs show how the precipitation is distributed throughout the year. All three show that over 30% of the precipitation comes during the summer months of July and August with July showing the highest precipitation for any single month. The winter months from November to March show precipitation of about 5 to 7% of the total for each month. No monthly records were ever kept for the Santa Fe Lake Station since it is inaccessible during the winter months; however, monthly records for this station would probably show a greater percentage of the total precipitation as snow during the winter months.



P STENDER

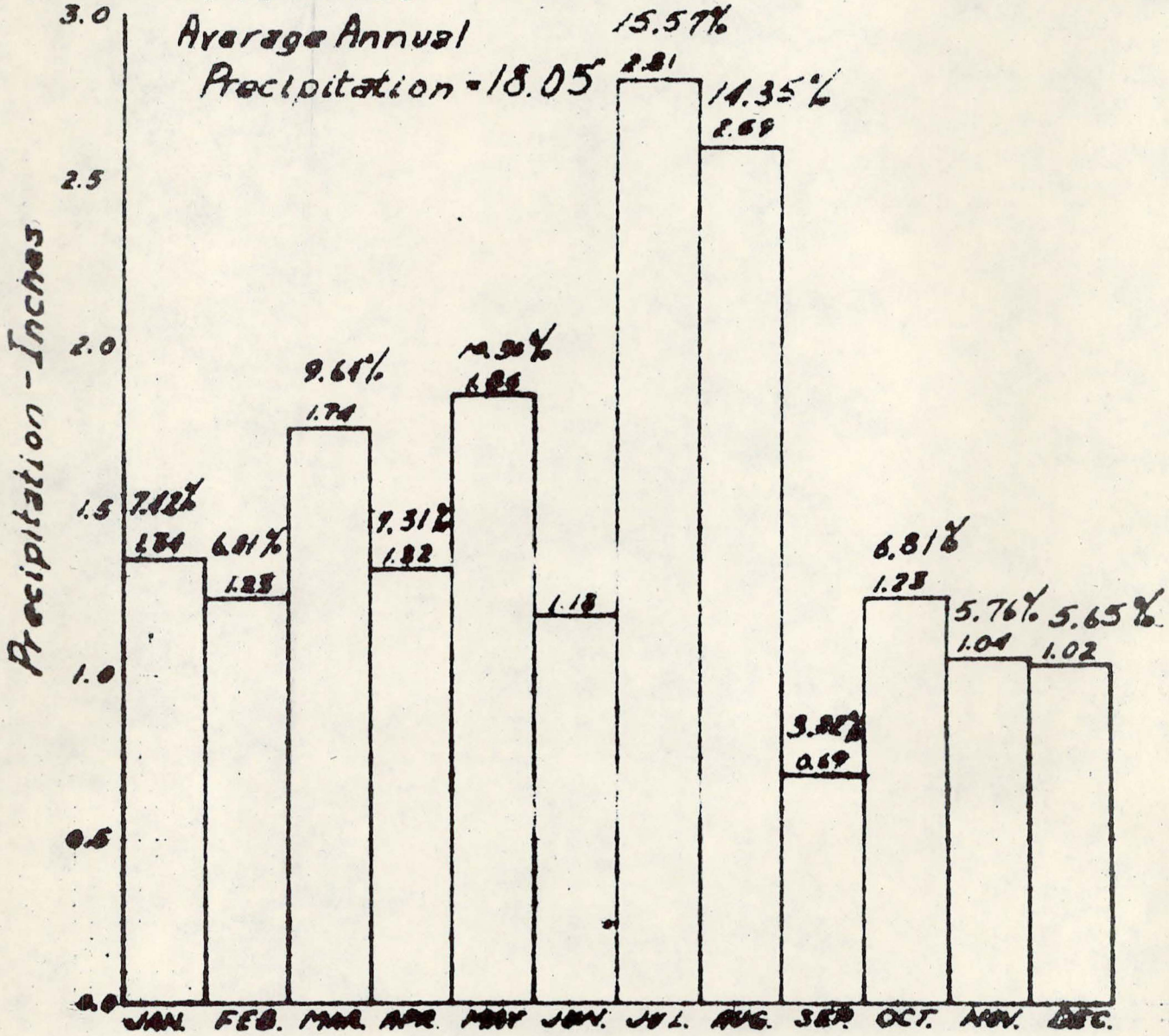
FROM CLIMATOLOGICAL SUMMARY - NEW MEXICO



P. STENDER

FROM CLIMATOLOGICAL SUMMARY - NEW MEXICO

Santa Fe Canyon - Elk Cabin
Elevation
Prorated Monthly Precipitation
1946 to 1955



FROM "PRECIPITATION DATA FROM STORAGE-GAGE STATIONS"

NUMBER 2 TO 23 - NEW MEXICO

Form of Precipitation

In the City of Santa Fe approximately 75% of the precipitation occurs during the period April through October. Thus 25% of the yearly precipitation would be snowfall. In Santa Fe Canyon the April October precipitation is 73%. This, however, is probably not entirely rain since the snowfall would begin earlier and last longer. The May through September precipitation, more representative of the rainfall received at this 8,400' elevation, is 53.8%. Thus the percentage of snowfall at this elevation is probably about 48%. Higher in the Watershed, toward Santa Fe Lake, the snowfall probably constitutes 60 to 75% of the total precipitation for the year.

Relation to Elevation

The chart on the next page gives an idea of the relation to elevation. Since there are no good records for the upper parts of the Watershed, the U. S. Geological Survey took precipitation records at selected stations throughout northern New Mexico to arrive at representative figures for the Santa Fe Watershed.[4]

Relation to Elevation

Altitude (Feet)	Area (Acres)	Mean Precipitation				Volume of Water		
		Oct - May		June - Sept		O-M	J-S	Total
		Inches	Feet	Inches	Feet	Acre-Feet	Acre-Feet	Acre-Feet
7718-8000	209	9.9	0.82	7.9	0.66	200	200	400
8000-9000	4,360	12.0	1.00	9.3	0.77	4,400	3,400	7,800
9000-10,000	3,360	16.4	1.37	11.8	0.98	4,600	3,300	7,900
10,000-11,000	2,200	22.5	1.88	15.1	1.26	4,100	2,800	6,900
11,000-12,409	1,450	32.8	2.73	20.0	1.67	4,000	2,400	6,400
Total	11,660					17,300	12,100	29,400
Percent						59	41	100

From: Water Supply Paper 1525 P. 154.

Design Rainfall

The chart shown on the next page gives design rainfall (in inches) for various durations and return periods. The duration is the length of time (in minutes or hours) that the storm lasts. This chart shows storms that last from 15 minutes to 12 hours. The return period is the expected frequency of a certain sized storm. Return periods are given for storms from 1 to 100 years. This information can be used in designing contour trenches and spillways. These design storms will generally be short duration summer thunderstorms.

Example:

A storm that is expected to come once in every ten year period and that lasts for one hour will produce 1.35 inches of rainfall.

Maximum Measured Storms for the Period 1909 to 1940 (32 Years)

5 Min.	0.46 Inches
10 Min.	0.62 Inches
15 Min.	0.77 Inches
30 Min.	1.03 Inches
1 Hour	1.16 Inches
2 Hours	1.65 Inches
24 Hours	2.83 Inches

From: Climatological Summary of Santa Fe, Page 15

Snowfall

As pointed out before, the percentage of snowfall ranges from about 25% in Santa Fe to about 65% towards the top of the Watershed near Santa Fe Lake.

The following tables were taken from the monthly publication of the Soil Conservation Service. The five locations are relatively near the Watershed and therefore give some indication of the amount of snow. It is recommended that these records be kept up-to-date so that long term averages can be computed. Another recommendation is that a snow course be established at an elevation higher than the Elk Cabin course since this is the zone of maximum snow accumulation.

DESIGN RAINFALL - INCHES

RETURN PERIOD	DURATION						
	15 MIN	30 MIN	1 HR	2 HR	3 HR	6 HR	12 HR
1	.32	.45	.60	.70	.80	.95	1.10
2	.43	.60	.75	.85	1.00	1.40	1.45
5	.65	.90	1.10	1.25	1.45	1.75	1.95
10	.75	1.05	1.35	1.60	1.80	2.00	2.40
25	.94	1.30	1.60	1.90	2.00	2.60	2.90
50	1.00	1.40	1.90	2.20	2.40	2.90	3.25
00	1.15	1.60	2.00	2.50	2.70	3.00	3.7

FROM: U.S. WEATHER BUREAU TECHNICAL PAPER #40
RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

ELK CABIN

New Mexico No. 5P4

Located on the Santa Fe National Forest about 10 miles from Santa Fe on Santa Fe Creek drainage in Sec. 8, T17N, R11E, elevation 8,250 feet. In area of heavy timber.

YEAR	FEBRUARY 1			MARCH 1			APRIL 1			MAY 1		
	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT
1948	2-01	16	4.1	3-01	24	6.6						
1949	1-31	15	3.2	3-01	19	5.2	4-01	11	2.2			
1950	2-01	12	2.3	2-28		.0	3-31		.0			
1951	2-01	7	.5	3-03		.0	4-01		.0			
1952	2-01	6	2.5	2-29	9	3.6	4-01	12	3.2			
1953	1-30	12	2.7	2-27	13	3.3	4-02		.0			
1954	1-30	11	3.1	3-01		.0	4		.0			
1955	2-01	8	1.4	3-02	12	4.1	3-30		.0			
1956	2-02	16	3.2	3-01	10	3.9	3-30		.0			
1957	1-31	7	2.6	3-01	3	1.4	3-27	2	1.2			
1958	1-30	13	3.8	2-28	14	4.0	3-31	21	8.2			
1959	2-03	5	1.4	2-27	6	2.0	4-01	3	1.1			
1960	1-27	17	5.3	2-28	25	6.5	3-30	12	5.0			
1961				2-27	15	3.8	3-30	6	1.7			
1962	1-29	16	3.9	2-26	10	3.8	3-29	8	3.2			
1963	1-30	12	3.2	2-28	13	3.6	3-29	5	2.0			
1964	1-30	6	1.3	2-27	14	2.5	3-31	11	3.6			
43-57 Ave			3.0			3.1			2.4			

ASPEN GROVE

New Mexico No. 5P1

Located on the Santa Fe National Forest near the head of Rio En Medio northeast of Santa Fe in Sec. 12, T18N, R10E, elevation 9,100 feet. In open park surrounded by heavy timber. Local drainage, Rio En Medio.

YEAR	FEBRUARY 1			MARCH 1			APRIL 1			MAY 1		
	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT
1937				3-04	19	4.4	4-03	7	2.2			
1938				2-28	7	1.7	3-31	1	.1			
1939	1-31	30	5.6	3-02	31	7.3	4-01	3	.8			
1940	1-31	12	3.3	3-01	22	5.2	3-30	9	2.9			
1941	2-01	31	8.0	2-28	32	9.8	3-31	32	10.3			
1942	2-02	12	3.0	3-04	17	3.8	4-01	16	4.4			
1943	2-03	24	4.6	3-01	18	4.4	4-01	11	3.0			
1944	1-31	22	4.8	2-29	24	6.0	3-31	18	5.6			
1945	1-31	24	5.7	2-28	24	5.7	4	26	7.3			
1946	2-01	12	2.8	3-01	10	2.7	4-01	5	1.4			
1947	1-31	11	2.1	2-28	11	2.1	4-01	3	.7			
1948	1-31	17	3.9	3-01	27	6.1	4-02	23	7.3			
1949	1-30	16	3.0	3-01	17	4.5	3-31	6	1.8			
1950	1-31	17	3.6	3-01	14	4.0	3-31	2	.6			
1951	1-28		.0	3-02	7	1.3	4-01		.0			
1952	2-01	11	3.4	2-28	19	5.0	4-01	13	4.3			
1953	2-01	16	4.1	2-28	23	6.5	4-02	39	1.7			
1954	1-30	13	2.7	3-01	9	2.0	3-28	5	1.8			
1955	1-29	10	1.8	3-01	14	3.1	3-31	3	.6			
1956	1-31	17	3.5	3-01	13	3.7	3-29		.0			
1957	1-31	14	3.5	3	17	4.3	3-28	12	4.3			
1958	1-31	16	3.9	2-28	18	4.5	3-31	24	7.5			
1959				3-02	13	2.3	3-31	9	2.0			
1960				2-26	30	8.7	3-29	18	6.1			
1961				2-24	13	2.4	3-28	12	4.6			
1962				2-26	32	9.7	3-29	19	5.8			
1963				2-26	24	8.3	3-26	17	7.1			
1964	1-31	12	1.9	2-26	20	4.5	3-25	11	5.3			
43-57 Ave.			3.2			4.1			2.7			

BIG TESUQUE
New Mexico No. 5F3X

Located on the Santa Fe National Forest about 16 miles northwest of Santa Fe in Sec. 17, T[illegible], R[illegible], elevation 10,000 feet. In wooded area of small aspen and scattered spruce and fir. Local drainage, Tesuque Creek.

YEAR	FEBRUARY 1			MARCH 1			APRIL 1			MAY 1		
	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT
1942	2-02	12	3.2	3-03	20	5.9	4-01	21	7.3			
1943	2-07	23	6.0	3-02	17	5.2	4-01	16	5.3			
1944	2-01	25	6.5	3-01	27	7.7	4-01	24	8.6			
1945	2-01	28	8.2	3-02	28	8.1	4-01	30	10.2			
1946	2-01	11	1.8	3-01	10	3.1	4-01	9	3.1			
1947	1-31	13	3.0	2-28	12	2.8	4-01	3	.7			
1948	1-31	16	4.3	3-01	34	8.2	4-01	31	10.7			
1949	1-30	25	5.9	3-01	27	7.6	3-31	17	5.2			
1950	1-31	20	4.4	3-01	17	4.8	3-31	2	.6			
1951	1-28	1	.2	3-01	6	1.1	4-01	2	.3			
1952	1-31	19	5.2	2-28	26	7.4	4-01	25	7.7	5-01		.0
1953	1-29	5	1.2	2-28	22	6.3	4-02	3	1.3			
1954	1-30	11	3.0	3-01		.0	3-28	9	3.4			
1955	1-28	12	2.1	2-28	15	3.2	3-31	2	.3			
1956	1-31	14	2.8	3-01	10	3.0	3-29		.0			
1957	1-31	17	4.5	2-27	8	2.7	3-28	15	5.8			
1958	2-01	17	5.0	2-26	23	6.2	4-01	30	9.5			
1959	1-30	7	2.5	3-02	6	1.3	3-31	4	1.0			
1960	1-28	24	7.1	2-25	31	7.0	3-28	21	6.9			
1961	1-30	8	2.0	2-27	12	2.6	3-28	17	5.9			
1962	1-29	24	5.2	2-26	23	6.8	3-29	21	5.6			
1963	1-30	19	5.2	2-26	23	7.4	3-26	16	6.0			
1964	1-29	7	1.8	2-28	19	5.0	3-24	20	6.4			
43-57 Ave			3.4			4.7			4.5			

RIO EN MEDIO

New Mexico No. 5P5M

Located on Santa Fe National Forest near the Aspen Basin Ski area in Sec. [illegible], T18N, R11E, elevation 10,400 feet. In widely scattered timber. Local drainage, Rio En Medio.

YEAR	FEBRUARY 1			MARCH 1			APRIL 1			MAY 1		
	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT	DATE	(inches) SNOW DEPTH	WATER CONTENT
1950	1-31	20	4.9	3-01	22	5.5	3-31	8	2.2			
1951	1-28	4	.2	3-01	14	2.9	4-01	8	1.0			
1952	1-31	20	5.9	3-01	30	9.4	4-01	35	9.2			
1953	1-30	21	7.8	2-28	30	7.1	4-02	21	8.6			
1954	1-29	21	4.6	3-01	18	5.3	3-28	22	6.8			
1955	1-29	14	2.4	3-01	23	4.4	3-31	12	2.9			
1956	1-31	22	4.6	3-01	22	6.6	3-29	4	1.4			
1957	1-31	24	6.5	2-27	23	7.6	3-28	30	11.0			
1958	2-01	25	6.3	2-26	34	10.1	4-01	50	13.4			
1959	1-30	12	4.8	3-02	16	3.6	3-31	16	4.1			
1960	1-29	32	9.4	2-25	42	11.4	3-28	8	1.9			
1961	1-30	18	4.2	2-27	29	6.5	3-28	28	6.6			
1962	1-29	34	9.0	2-26	32	9.7	3-29	37	10.6			
1963	1-30	26	7.5	2-26	39	10.5	3-26	33	11.7			
1964	1-29	15	4.0	2-26	26	6.4	3-24	29	8.9			
43-57 Ave			5.3			6.8			5.8			

Evaporation

McClure Reservoir & Nichols Reservoir and Two Mile Reservoir

Pan Elevation = 7000'

Surface Areas:

		Pan Coef.
7885' McClure Reservoir	80 Acres	0.60
7488' Nichols Reservoir	25 Acres	0.70
7360' Two Mile Reservoir	20 Acres	0.70

	* Pan. Evap. (In.)	Pan. Evap. (Ft.)	Pan. Coef.	Total Lake Evaporation (Ft.)
April	6.14	.511	0.60	.306
			0.70	.358
May	8.51	.709	0.60	.425
			0.70	.495
June	10.14	.845	0.60	.507
			0.70	.591
July	8.93	.735	0.60	.441
			0.70	.514
Aug.	8.06	.671	0.60	.403
			0.70	.470
Sept.	6.51	.545	0.60	.327
			0.70	.381
Oct.	4.81	.401	0.60	.251
			0.70	.280

* 1917 to 1926 Averages for Santa Fe

Evaporation from McClure Reservoir

April	.306	x	80	=	24.4	Acre Feet
May	.425	x	80	=	34.0	Acre Feet
June	.507	x	80	=	40.6	Acre Feet
July	.441	x	80	=	35.3	Acre Feet
Aug.	.403	x	80	=	32.2	Acre Feet
Sept.	.327	x	80	=	26.2	Acre Feet
Oct.	.251	x	80	=	20.1	Acre Feet
Total					212.8	Acre Feet

Evaporation from Nichols Reservoir

April	.358	x	25	=	8.9	Acre Feet
May	.495	x	25	=	12.4	Acre Feet
June	.591	x	25	=	14.8	Acre Feet
July	.514	x	25	=	12.8	Acre Feet
Aug.	.470	x	25	=	11.8	Acre Feet
Sept.	.381	x	25	=	9.5	Acre Feet
Oct.	.280	x	25	=	7.0	Acre Feet
Total					77.2	Acre Feet

Evaporation from Two Mile Reservoir

April	.358	x	20	=	7.2	Acre Feet
May	.495	x	20	=	9.5	Acre Feet
June	.591	x	20	=	11.8	Acre Feet
July	.514	x	20	=	10.3	Acre Feet
Aug.	.470	x	20	=	9.4	Acre Feet
Sept.	.381	x	20	=	7.6	Acre Feet
Oct.	.280	x	20	=	5.6	Acre Feet
Total					61.4	Acre Feet

Grand total 351.4 Acre Feet

Water Year	Runoff Acre Feet	Runoff Inches		
1914	8,680	7.40		
1915	13,050	11.12		
1916	12,610	10.75		
1917	3,420	2.91		
1918	4,740	4.04		
1919	18,990	16.18		
1920	7,900	6.74		
1921	16,620	14.16		
1922	3,590	3.06		
1923	4,790	4.08		
1924	7,840	6.77		
1925	1,780	1.52		
1926	9,140	7.79		
1927	4,450	3.79		
1928	4,700	4.01		
1929	8,490	7.24	Watershed Area = 22 Sq. Mi.	7.22
1930	6,220	6.67		
1931	7,200	7.72		
1932	7,660	8.13		
1933	2,890	3.01		
1934	1,930	2.07		
1935	6,220	6.59		
1936	6,380	6.75		
1937	7,680	8.13		
1938	3,000	3.11		
1939	5,040	5.32		
1940	5,420	5.71		
1941	14,120	14.90		
1942	12,240	13.01		
1943	3,960	4.17		
1944	5,220	5.59		
1945	6,680	7.16		
1946	2,910	3.11		
1947	3,490	3.74	Watershed Area = 17.5 Sq. Mi.	6.38
1948	5,340	5.30		
1949	7,210	7.43		
1950	1,550	1.60		
1951	1,600	1.65		
1952	4,870	5.02		
1953	2,340	2.41		
1954	2,080	2.14		
1955	2,500	2.58		
1956	1,020	1.05		
1957	6,440	6.64		

Watershed Area = 18.2 Sq. Mi.

Runoff

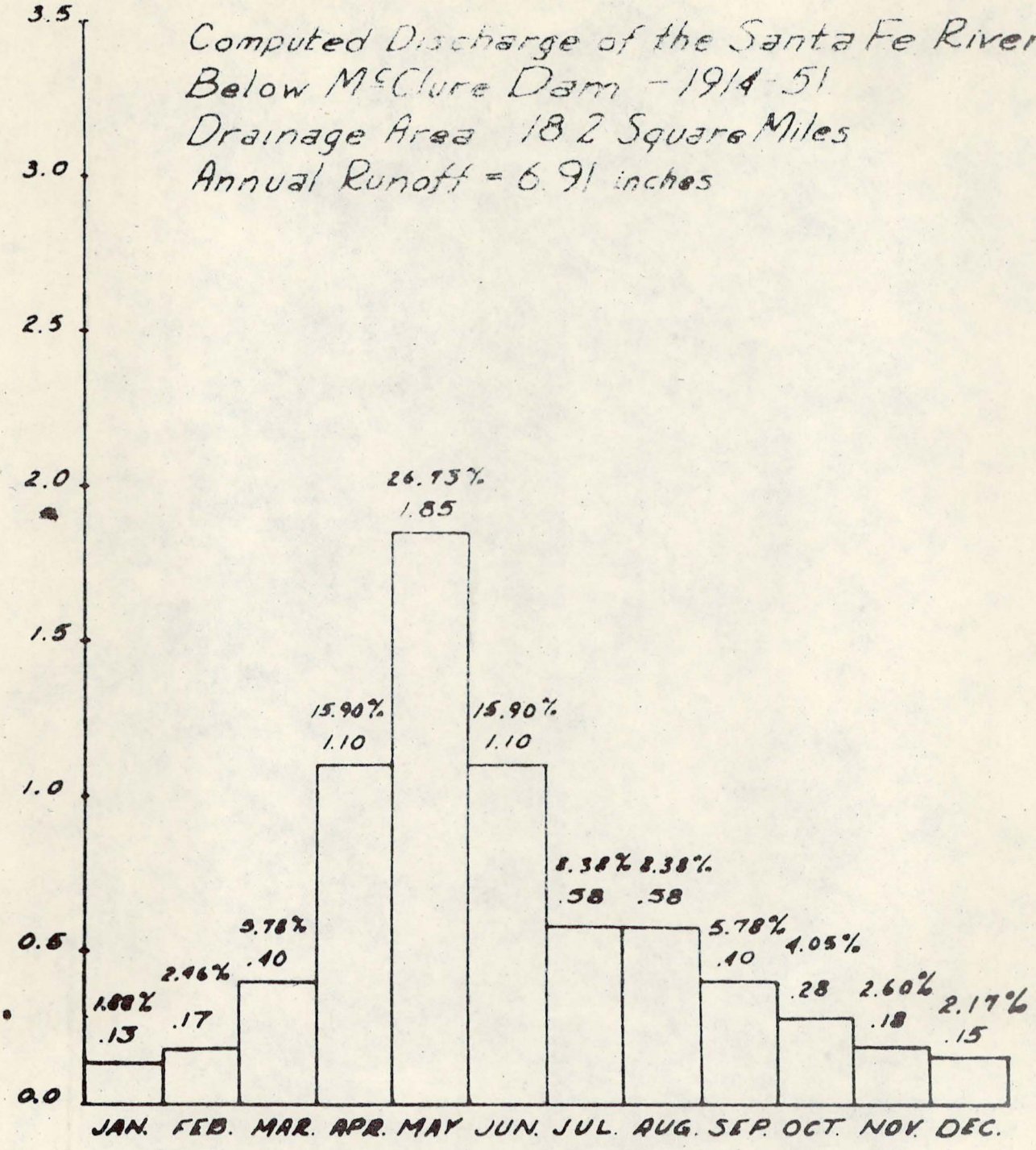
The earliest continuous stream gaging records were collected at the present site of Nichols Reservoir from April 1913 to November 1930. This constitutes a Watershed area of 22.0 square miles. From November 1930 to October 1947 the stream gaging station was moved upstream to a point located 300 feet downstream from McClure Reservoir. At this location 17.5 Square Miles of Watershed drained into the gaging station. Since October 1947, the gaging station was moved downstream to a point 0.4 mile below McClure Reservoir. The area above this station is 18.2 square miles. Since runoff is controlled by McClure Reservoir, corrections have been applied to the runoff figures to account for change in storage and evaporation. The corrected runoff figures have been changed to inches.[5] This provides an easy comparison between precipitation and runoff. (See Appendix I)

Types of Flow

The bar graph on the following page shows that the months of April, May, and June account for close to 60% of the total annual flow. The winter months from November through February account for less than 3% for each of those months.

The chart on the page following shows the runoff by month, the precipitation by month for Santa Fe and Elk Cabin and the ratio of the runoff to the precipitation for each station. The months that show a high figure for the ratio are the months highest runoff. This runoff can only be accounted for by snowmelt. It can also be noted that the months of highest snowmelt, April, May, and June are the months that have the prevailing wind direction from the southwest.

Computed Discharge of the Santa Fe River
Below McClure Dam - 1914-51
Drainage Area 182 Square Miles
Annual Runoff = 6.91 inches



For period from April 1926 to date, discharge is corrected for evaporation from McClure Res.

From: Geology & Water Resources of the Santa Fe Area, New Mexico. Geological Survey Water Supply Paper 1525, P. 250

STENDER

Hydrograph Analysis

"The flow of the Santa Fe River is sustained by ground-water discharge from glacial deposits and from soil, weathered zones, and fractures in the Pre-Cambrian rocks of the Sangre de Cristo Mountains. As the ground water accretion to the stream, or base flow, varies with water levels in the ground-water reservoirs tributary to the stream, base flow is a variable amount. Although the snowmelt runoff in April, May, and June is responsible, on the average, for approximately half the annual surface runoff, and substantial parts of the precipitation for the remainder of the year are discharged as direct runoff, base flow probably contributes 20 - 25 percent of the average annual runoff, 100 percent of the flow in long dry periods within the year, and as much as 60% of the total runoff in drought years. Ground water accretion is thus the stabilising factor that maintains flow during dry periods." [6]

Various methods of hydrograph separation have been applied to certain hydrographs of the Santa Fe River. No definite conclusions have been reached since the hydrographs show such sharp peaks. It is also difficult to separate surface runoff from base flow with a compound hydrograph.

HYDROGRAPH OF STORM OF JUNE 16, 1914

	Gage Height		Corrected G. H.	Discharge (c.f.s.)
7PM	1.48		1.61	15.6
8	1.50		1.63	16.8
9	1.70		1.83	30.4
9:30	2.82	Add .13	2.95	226 *
10	2.05		2.18	67.8
11	1.87		2.00	45.0
12M	1.85		1.98	43.2
1AM	1.83		1.96	41.4
2	1.81		1.94	39.6
3	1.78		1.91	36.9
4	1.74		1.87	33.6
5	1.72		1.85	32.0
6	1.70		1.83	30.4
7	1.69		1.82	29.6
8	1.69		1.82	29.6
9	1.68		1.81	28.8
10	1.67		1.80	28.0
11	1.66		1.79	27.3
12N	1.65		1.78	26.6
1PM	1.63		1.76	25.2
2	1.62		1.75	24.5
3	1.61		1.74	23.8

* From Page 445 of WSP #1312

Revision dates and composite measurements 1915-21 and revise dates Aug 1-15, 1921.

D-810
(Sept 1952)

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File No. Washington
Field

Rating table for Santa Fe Creek near Santa Fe, N. Mex

..... , from ..... , 19 ..... , to ..... , 19

Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference	Gage height	Discharge	Difference
Feet	C/s	C/s	Feet	C/s	C/s	Feet	C/s	C/s	Feet	C/s	C/s	Feet	C/s	C/s
1.00			3.00	240	35	5.00	1,350	90	.00			.00		
.10	0.7	1.2	.10	275	35	.10	1,440	100	.10			.10		
.20	1.9	1.9	.20	310	40	.20	1,500		.20			.20		
.30	3.8	2.8	.30	350		.30			.30			.30		
.40	6.6	3.7	.40	390		.40			.40			.40		
.50	10.3	4.7	.50	430		.50			.50			.50		
.60	15	6	.60	470	40	.60			.60			.60		
.70	21	7	.70	510	50	.70			.70			.70		
.80	28	8	.80	560		.80			.80			.80		
.90	36	9	.90	610		.90			.90			.90		
2.00	45	10	4.00	660	50	.00			.00			.00		
.10	55	12	.10	710	60	.10			.10			.10		
.20	67	14	.20	770	60	.20			.20			.20		
.30	81	16	.30	830	60	.30			.30			.30		
.40	97	18	.40	890	70	.40			.40			.40		
.50	115	20	.50	960	70	.50			.50			.50		
.60	135	22	.60	1030	70	.60			.60			.60		
.70	157	25	.70	1100	80	.70			.70			.70		
.80	182	28	.80	1180	80	.80			.80			.80		
.90	210	30	.90	1260	90	.90			.90			.90		

The above table is not applicable for ice or obstructed channel conditions. It is based on ..... discharge measurements made during (1913-1921) Nos. 23-227

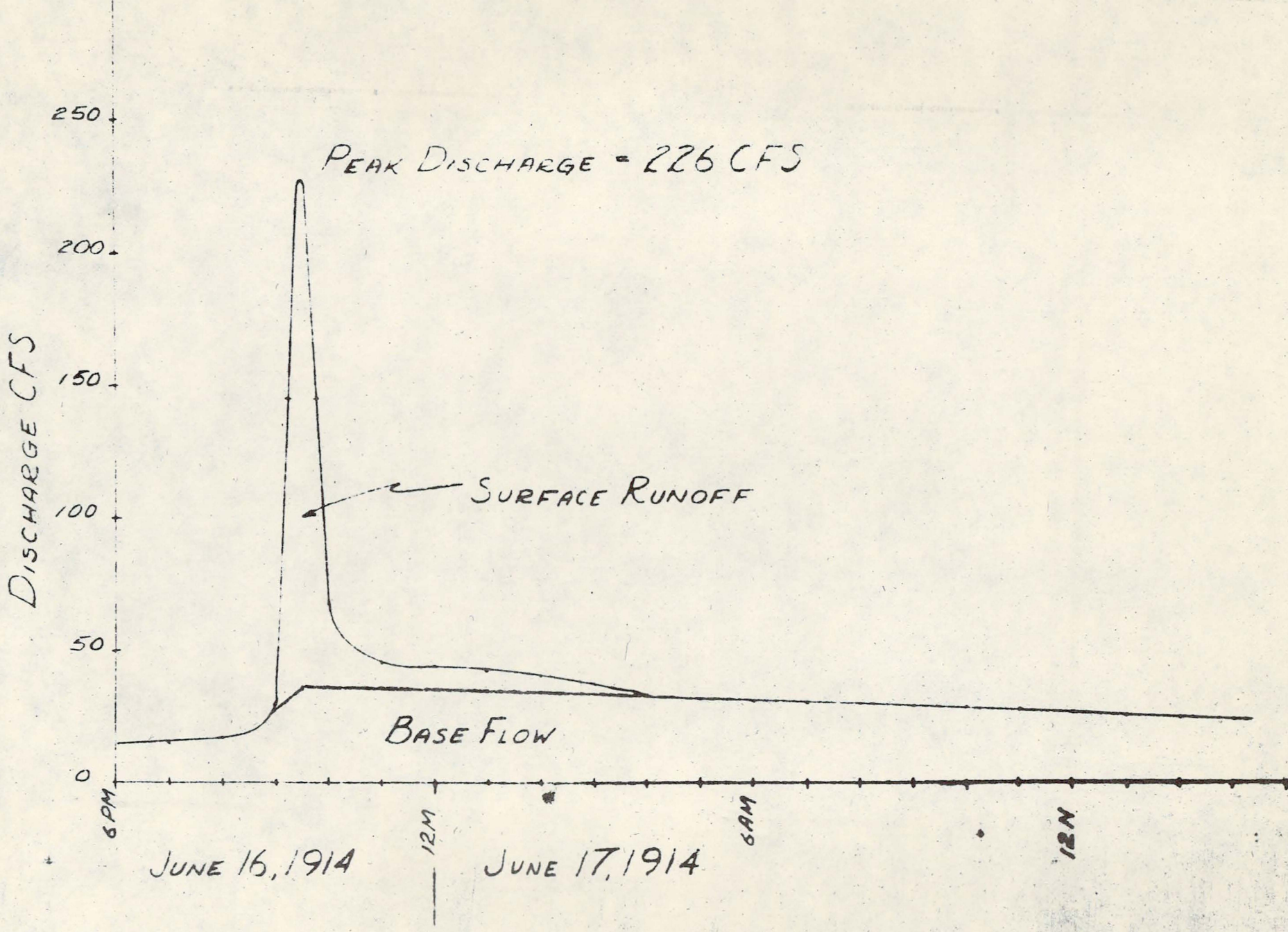
and is well defined between 1 cfs and 150 cfs.

and extended above 150 cfs by logarithmic plotting.

Computed by [illegible]

Checked by [illegible]

Date Sept 29 [illegible]


250
200
150
100
50
0
DISCHARGE CFS
PEAK DISCHARGE = 226 CFS
SURFACE RUNOFF
BASE FLOW
6 PM
12M
6AM
12N
JUNE 16, 1914
JUNE 17, 1914

HYDROGRAPH OF THE STORM OF AUGUST 1, 1919

		Corrected Gage Height (.2' Added for Correction)		Discharge (cfs)
July 31, 1919				
12N		1.85		32.0
1PM		1.86		32.8
2		1.87		33.6
3		1.88		34.4
4		1.89		35.2
5		2.00		45.0
6		2.04		49.0
6:30		2.27		76.8
7		2.21		68.4
8		2.04		49.0
9		2.01		46.0
10		1.99		44.1
11		1.96		41.4
12M		1.95		40.5
August 1, 1919				
1AM		1.96		41.4
2		1.96		41.4
3		2.17		63.4
4		2.43	Small Peak	102.4
5		2.43		102.4
6		2.52		119.0
7		2.62		139.4
8		2.61		137.2
9		2.56		127.0
10		2.50		115.0
11		2.46		107.8
12N		2.43		102.4
1PM		2.42		100.6
2		2.42		100.6
3:15	Peak	2.72		162 *
4		2.52		119.0
5		2.59		133.0
6		2.58		131.0
7		2.58		131.0
8		2.57		129.0
9		2.57		129.0
10		2.57		129.0
11		2.56		127.0
12M		2.56		127.0
August 2, 1919				
1AM		2.56		127.0
2		2.55		125.0
3		2.54		123.0
4		2.54		123.0

HYDROGRAPH OF THE STORM OF AUGUST 1, 1919 (continued)

August 2, 1919	Corrected Gage Height	Discharge (cfs)
5	2.53	121.0
6	2.53	121.0
7	2.52	119.0
8	2.52	119.0
9	2.52	119.0
10	2.51	117.0
11	2.50	115.0
12N	2.48	111.4
1PM		
2	Drops .2 ft. from 12N Aug. 2 to 12N Aug. 4 (fairly constant drop)	
August 4, 1919		
12N	2.28	78.2

*From Page 445 WSP 1312

Streamflow Forecasting

The charts and graphs used in this section can be used to give an approximation of the streamflow that might occur from the watershed. However, it must be remembered that these figures were obtained from previous records and may not be applicable to future predictions. In other words, the past records may have been collected during a dry or a wet cycle or certain watershed characteristics may have changed. At any rate, future records, should be included in the analyses to increase the accuracy.

Streamflow even on perennial streams is very variable. Monthly and yearly mean discharges in cubic feet per second are given on pages 443-444 in U.S.G.S. Water-Supply Paper 1312 and on page 410 in U.S.G.S. Water-Supply Paper 1732. Monthly and yearly discharges in acre-feet are given on the same pages. The maximum and minimum flows for each year are given on page 445 in WSP 1312 and on page 410 in WSP 1732. From 1914 to 1960 the momentary maximum discharge was 1,500 cubic feet per second which occurred on August 14, 1921. Without the regulation of McClure reservoir the flood of September 23, 1923 might have exceeded 1,500 cubic feet per second. The minimum daily discharge during the same period was 0.1 cubic feet per second. This low flow occurred on February 7-10, 20, 21, 1927 and August 1-4, 1951. These figures show the variability that might be expected in the streamflow. Although the greatest volume in sustained flow comes during the months of April, May, and June, the highest peak flows come during the summer months as a result of summer thunderstorms.

Low flows usually take place during the winter months when there is little precipitation and little snowmelt.

Three types of predictions are shown on the graphs on the following pages and are discussed below.

(1) Flow Duration Curve

This graph shows the percent of time that a certain daily discharge was equaled or exceeded during the period 1913 to 1926. This curve is useful for the prediction of the availability and variability of future flows. The shape of the curve reflects the characteristics of the basin. Thus, flow duration curves are different for different watersheds.

Examples:

(a) Ninety percent of the time the flow can be expected to be equal to or greater than 1.55 cubic feet per second.

(b) Twenty percent of the time the flow can be expected to be equal to or greater than 17.5 cubic feet per second.

(2) High Flow Frequency Curves

Three curves relate rate of high flow to the corresponding average number of years between exceedence of this rate. This recurrance

interval (T_r) is computed by the formula $(n+1)/M$, where n is the years of record, and M is the order of magnitude, the highest being 1. The mean discharge in cubic feet per second was changed to acre-feet.

The curves show the average number of years between exceedences; however, two such exceedences may occur in succeeding years.

Examples:

(a) Over a three day period 1000 acre-feet will be exceeded, on the average, every 8.5 years.

(b) Over a fifteen day period 3000 acre-feet will be exceeded, on the average, every 6 years.

(c) Over a seven day period 1500 acre feet will be exceeded, on the average, every 4.6 years. (Basic data and computation shown in Appendix II).

3. Runoff Prediction for Santa Fe River

Since the major portion of the April to July runoff originates from the melting of the winter snowpack, the runoff for this period can be correlated with the water content of the snowpack on April 1st. The April to September runoff was not used because much of the runoff during this period is influenced by the amount of precipitation that comes during the summer months. Also the bulk of the annual runoff (approximately 68.5%) comes during the three months of April, May, and June. The months of July and August together supply only about 16.8% of the average annual runoff. The greater part of the 68.5% comes from the melting of the snowpack. There is no way of knowing just how much of the 16.8% is influenced by the snowpack and how much is influenced by the summer thunderstorms. Corrected runoff figures for the Santa Fe River were taken from A Study of Water Yield from the Santa Fe Watershed, by George D. Hardaway and J. Robert Thompson. Runoff Figures in acre-feet were added during the period of April, May and June for each year from 1942 to 1957 (16 years). These figures were then converted to area-inches. Taking an area of approximately 18 square miles:

1 inch on 1 square miles = 53.3 A.F.
1 inch on 18 square miles = 959.4 A.F.

Three snow courses are located near the watershed. They are:

Rio En Medio	1950-1964
Big Tesuque	1942-1964
Aspen Grove	1939-1964

Because the course at Rio En Medio has a shorter period of record, it was thrown out and the readings for April 1st of Big Tesuque (elevation 10,000 ft.) and Aspen Grove (elevation 9,100 ft.) were averaged for each year from 1942 to 1957. These figures were used as the X-valve while the area-inches of runoff was used as the Y-valve. From this information a prediction line can be determined.

Information from snowpack measurement and runoff in following years should be used to refigure the prediction line. Runoff measurements are presently being taken by the U.S.G.S. below McClure Reservoir. The figures must be corrected for evaporation and for storage. Measurements of flow are presently being taken by the Public Service Company just above McClure Reservoir; however, these records have been collected for only a short period of time. As this period of record increases, this data may be very useful because no corrections for evaporation and storage will be needed.

Example:

From snow course measurements on April 1 it is determined that the water content is 4.2 inches at Big Tesuque and 3.6 inches at Aspen Grove. The average water content is 3.9 inches. From the prediction line it is determined that there will be 2.57 area-inches of runoff from April 1 to July 1. To convert this figure to acre-feet, multiply by 959.4. The predicted runoff is 2456 acre-feet.

(Basic Data and Computations shown in Appendix III)

UNITED STATES DEPARTMENT OF THE INTERIOR
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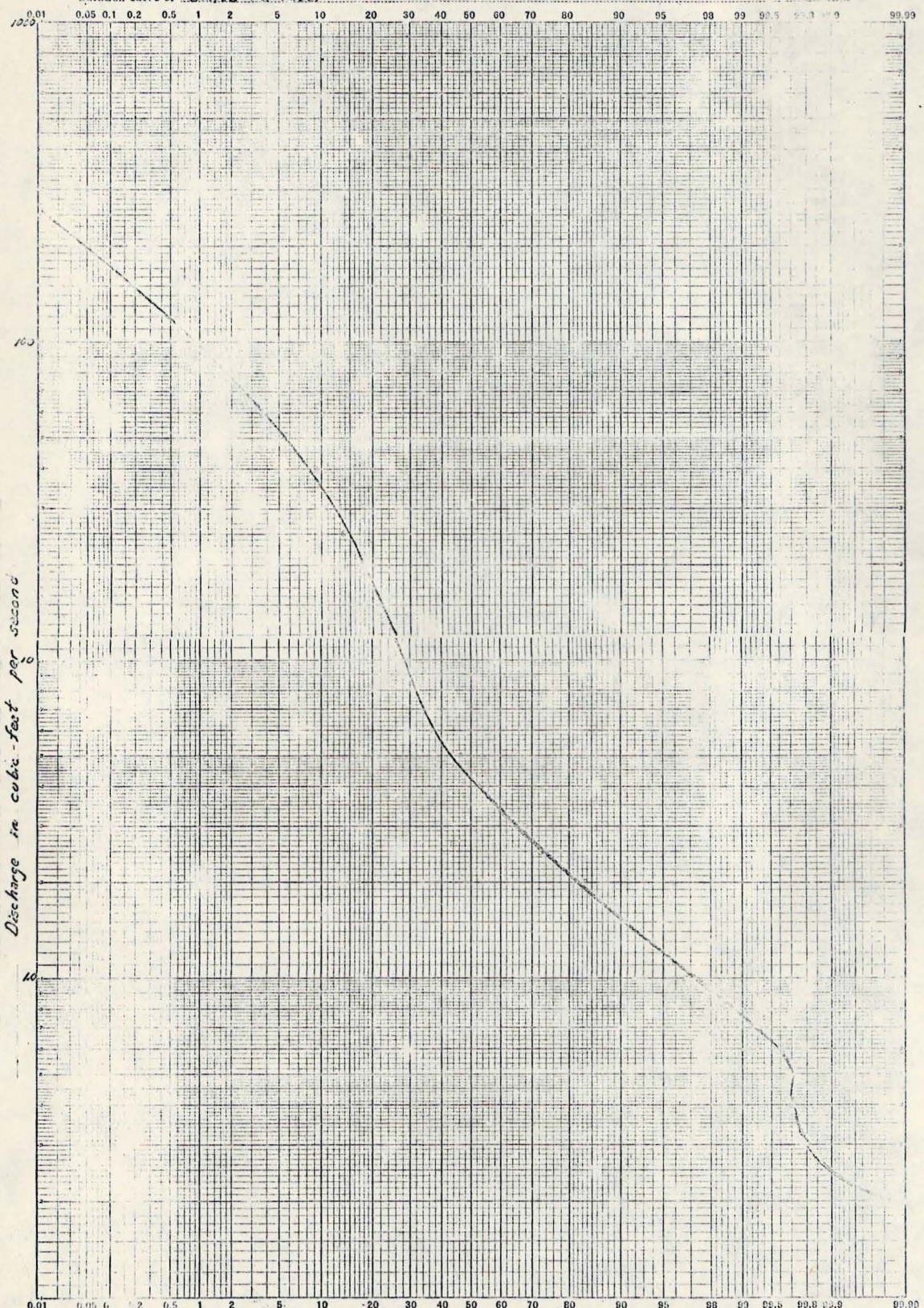
Duration curve of Santa Fe River



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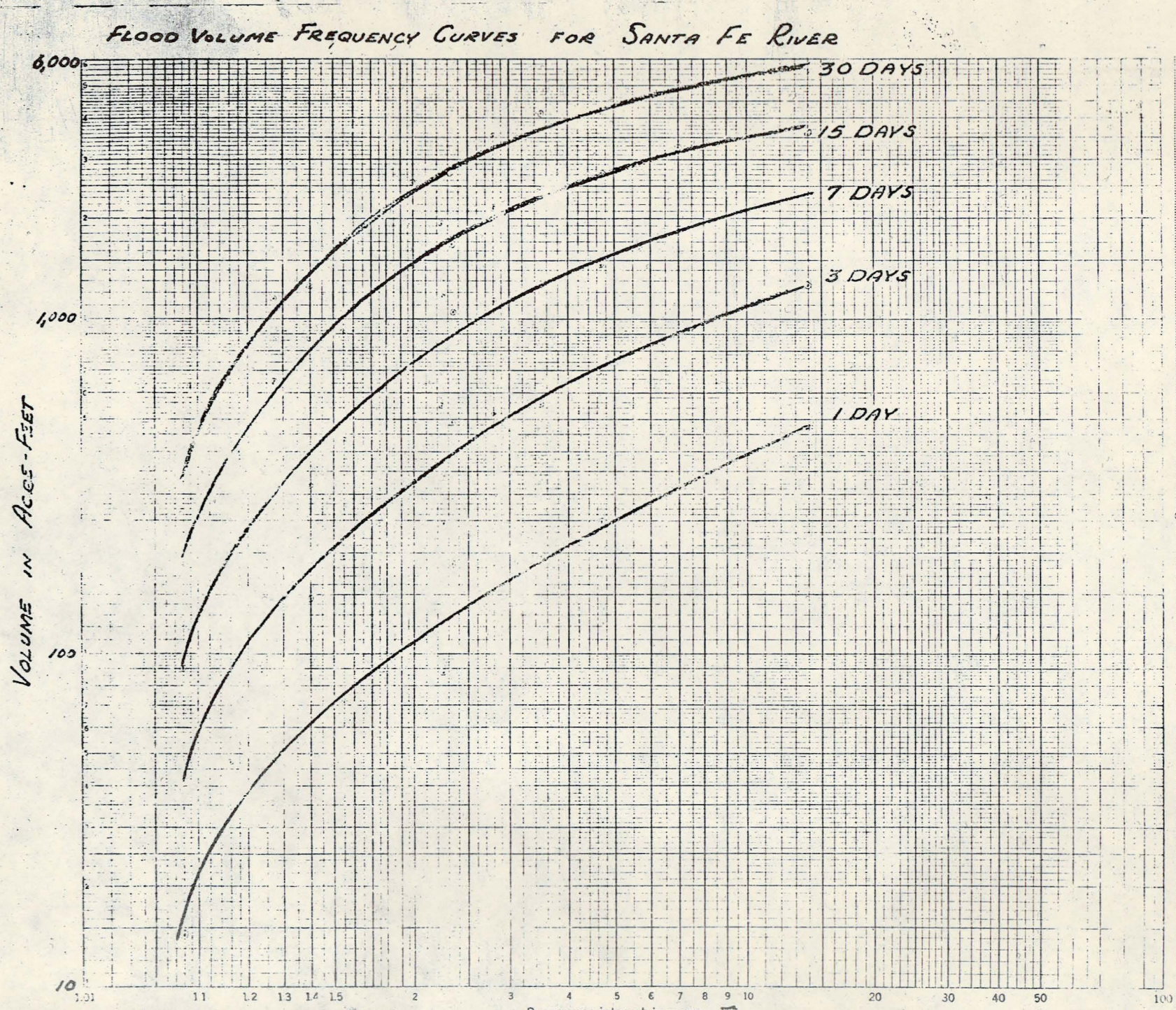


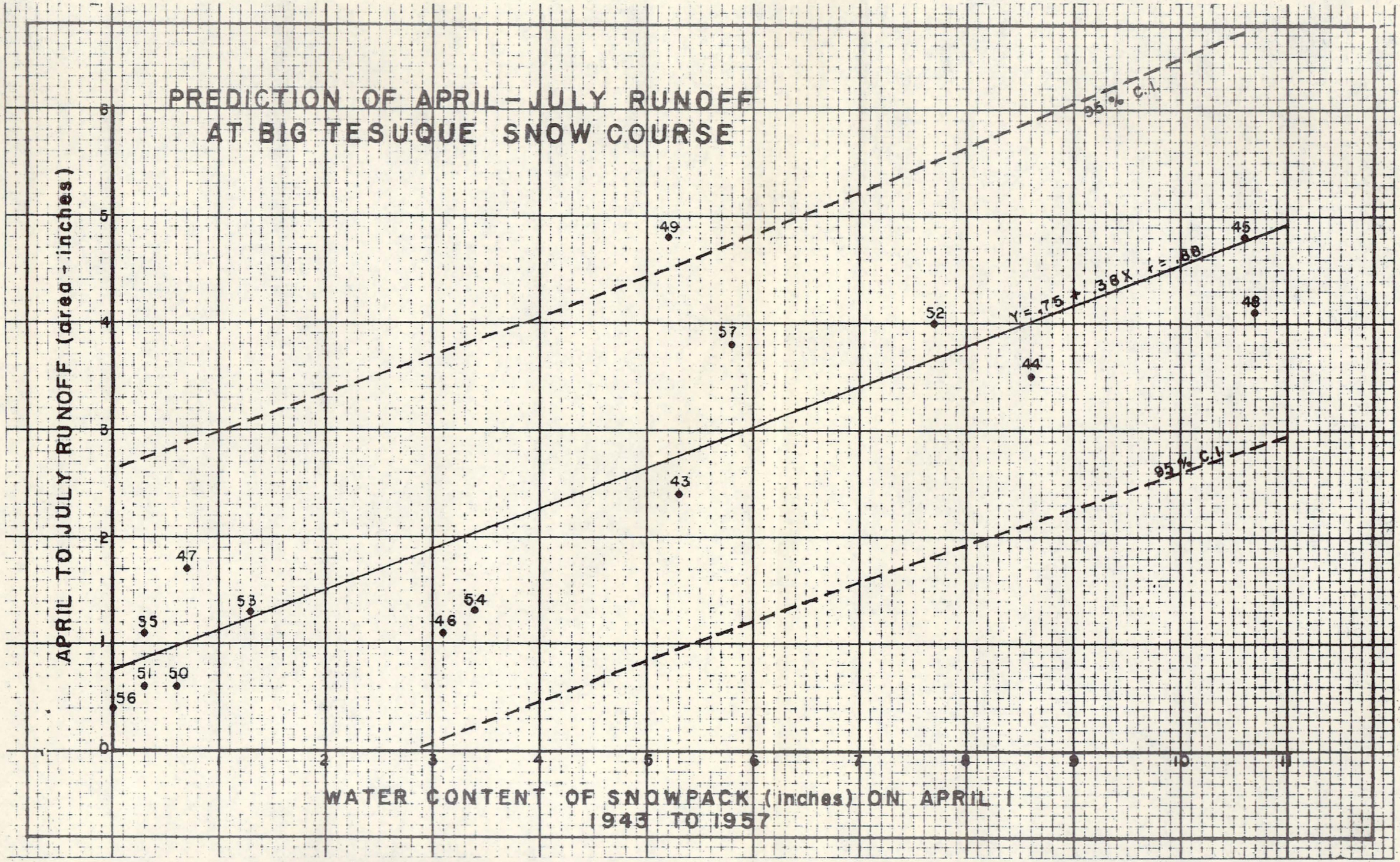
9-179b
Extreme log data plot
April 1955

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File

Magnitude and frequency of FLOOD VOLUMES on SANTA FE RIVER

Drainage ... sq. mi. Period 1913 to 1926


PREDICTION OF APRIL-JULY RUNOFF
AT BIG TESUQUE SNOW COURSE
APRIL TO JULY RUNOFF (area - inches)
WATER CONTENT OF SNOWPACK (inches) ON APRIL 1
1943 TO 1957
95 % C.L.
95 % C.L.
Y = .75 + .38X r = .88
0
1
2
3
4
5
6
7
8
9
10
11
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57

USES IN THE WATERSHED

From a report of the Forest Supervisor on July 2, 1926:

Forest Management

"Past History - Santa Fe Canyon being the most accessible area to the City of Santa Fe for timber and cordwood was cut out long ago, at first the finer trees being taken but later practically all was cut that would make cordwood, leaving the canyon almost bare of any tree growth up five miles above its mouth. Under Forest Service restrictions total protection was given what little timber remained and the comparatively light use by stock has resulted in a fair stand by yellow pine reproduction on the south hill side. The north hill side still has practically no ground cover except scattering pinon, juniper, and mahogany bushes. The creek bottom has no shrubby growth except in the Ranger Station pasture which was fenced fifteen years ago and has been protected from unregulated grazing since. Here an excellent stand of alder and willow has been established in the gravel beds and indicate clearly what can be expected in the way of erosion control if the creek bottom is protected from grazing."

Grazing

"Past History - Some time after the establishment of the town in 1606, the Santa Fe Canyon was used for grazing milk and work animals owned by the local residents. This use was unrestricted and unregulated resulting in serious depletion of the herbacious vegetation and erosion which annually caused material reduction in the volume of water in the New Mexico Power Company's reservoir by silting. With the advent of Forest Administration this excessive use was somewhat reduced and ten years ago all stock grazing was excluded. From then until 1924 trespass cattle and horses have used the private lands in the bottom of the canyon without molestation due to the fact that no formal agreement existed under the terms of which the Forest Service could administer these lands. In the summer of 1924 a special patrol, sanctioned by the Water Company, kept most of the stock driven out of the canyon. The State Health Department's examinations of the city water supply for that year showed a considerably lower bacterial count than had ever before been known in spite of the fact that it was a very dry year and the reservoir practically empty. The Health Department attributed this satisfactory condition directly to the lack of stock on the watershed."

C
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Record of Bacteriological Analyses of the Santa Fe City Water Supply 1920–1931, Inclusive

Supplied by

New Mexico Bureau of Public Health
Division of Sanitary Engineering and Sanitation
Paul S. Fox, C. E., Chief

Year	No. Samples	Av. Bact. Count per cc.	% of Portions of Samples Showing B. Coli 10cc.	1 cc.	0.1 cc
1920	8	270	57%	44%	0%
1921	10	415	52	35	0
1922	24	1910	35	23	4
1923	1	no count	0	0	0
1924	7	70	54	0	0
1925	23	2450	18	0	0
1926	32	260	9	0	0
1927	50	65	6	2	0
1928	79	38	3	0	0
1929	78	19	7	0	0
1930	94	133	1	0	0
1931	136	61	5	1	0

In the routine bacteriological examination of water samples it is our custom to examine two 1 cubic centimeter portions from each sample in order to determine the total count of bacteria; five 10 cubic centimeter portions and two 1 cubic centimeter portions, and occasionally two 0.1 cubic centimeter portions, in order to determine the presence or absence of organisms of the B. Coli group. The percentages shown in the last three columns indicate the percentage of the portions which contained B. Coli.

B. Coli (colon bacillus) are rather widespread in nature, occurring in the intestinal tract of most warm blodded animals and to a certain extent upon grains and some other types of vegetation. Regardless of the fact that B. Coli is sometimes found in the soil and on vegetation. Water analysts have laid down this law: The presence of B. Coli in a large proportion of small samples (1 cc or less) of water examined is indicative of more or less recent sewage pollution. "Sewage" in this case is interpreted to mean the fecal discharge of humans and warm blooded animals. B. Coli in a stream are out of their natural environment and consequently they die off rather rapidly.

By 1925 standards of the U. S. Public Health Service, the water of the Santa Fe watershed did not pass specifications while cattle were permitted in the watershed.

1. Total count of bacteris shall not be over 100 per cc.

2. Not more than one of five 10 cc portions of any one sample shall contain B. Coli.

In 1932, at the request of the City Council, the Secretary of Agriculture prohibited bathing, fishing, picnicking and other forms of human use on the Government owned lands.

In 1942 the canyon was examined to determine ways in which silt production could be reduced. This project was to be in coordination with the new Nichols reservoir which was put into operation in 1943. In 1947 McClure reservoir, which was first built in 1926, was raised to its present capacity. The following report was made by W. G. Koogler in 1942 to determine the condition of the watershed and to determine how to reduce siltation:

> "Throughout the mountainous watersheds of the canyon a decomposed granite type is the dominant formation. Shallow soils of the low mountains are characteristically coarse intermixed with granitic gravel and sand. Following as an inevitable consequence of past over-grazing and cover depletion these coarse relatively sterile granitic soils reflect serious loss of fertility.
>
> "Canyon bottoms and the narrow valley floors of the larger tributaries preserve a much more fertile alluvial soil. These bottom soils, although not infrequently covered over or intermixed with coarse material from adjacent slopes and drainage channels have made excellent vegetative recovery under protection.
>
> However, after 16 years of total rest, large slope areas are still barren--the coarse gravel forming on erosion pavement that constitutes a harsh and forbidding seed bed. On such areas, top soils are generally too unstable to permit the establishment of shallow, surface rooted vegetation. Logged over many years ago, a most encouraging development of recent years has been the natural establishment of tree reproduction in many places on these steep barren slopes. Some of the tree planting of a few years ago has also been successful. Throughout the watershed are examples of the protection afforded the slopes under advanced forest cover."

From these two observations at two different periods in the history of the watershed it is apparent that closure of the watershed helped mainly in the fertile alluvial bottomlands, but many of the side slopes had not recovered by the observation made in 1942. At the time of this report (1964) the condition of the watershed is very similar to that described in 1942. There are still many steep, bare hillsides while the ground cover density along the Santa Fe River is approaching 100 percent. The barren areas on the hillsides seem to be occurring on slopes greater than 50 to 60 percent. Apparently the litter can build up on slopes less than 50 to 60 percent.

Since the closing order by the Secretary of Agriculture in 1932 this area has been closed to all uses except for the production of water.

Water Use

The following charts from the files of the Public Service Company in Santa Fe show the increasing demand for water from 1957 to 1963.

	Total - Thousand Gallons Sold
1957	1,107,490
1958	1,172,281
1959	1,259,181
1960	1,285,735
1961	1,255,438
1962	1,461,658
1963	1,499,542

Refer to Appendix Table No. IV

Monthly figures for the most recent complete year show that May through September are the months of heaviest water use. The following table shows the breakdown by months:

	Thousand Gallons of Water Sold
Jan	77,138
Feb.	70,544
March	68,593
April	103,773
May	159,270
June	180,291
July	197,951
Aug.	176,777
Sept.	143,196
Oct.	125,355
Nov.	98,292
Dec.	98,362

Refer to Appendix Table No. IV

The previous tables show that there is a definite increase in water use especially during the summer months.

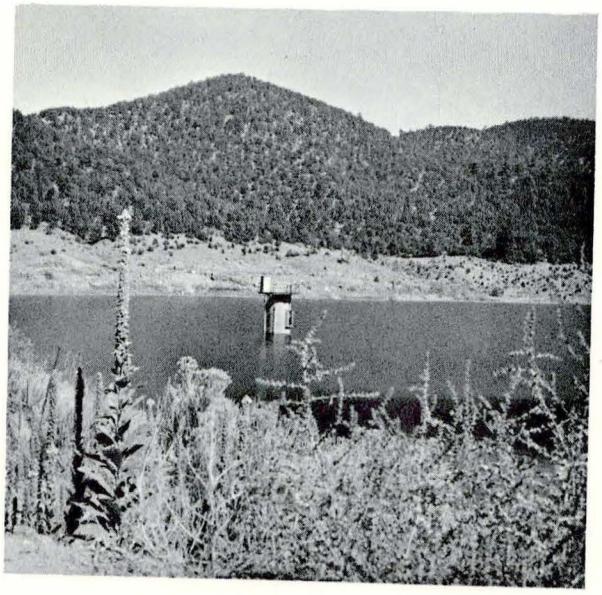
POINTS OF INTEREST

(1) Two Mile Reservoir

Picture taken July 1964

This is the lowest reservoir within the Watershed boundary. It has approximately 20 surface acres and capacity of 406 acre-feet. It was built in 1894.

(2) Nichols Reservoir

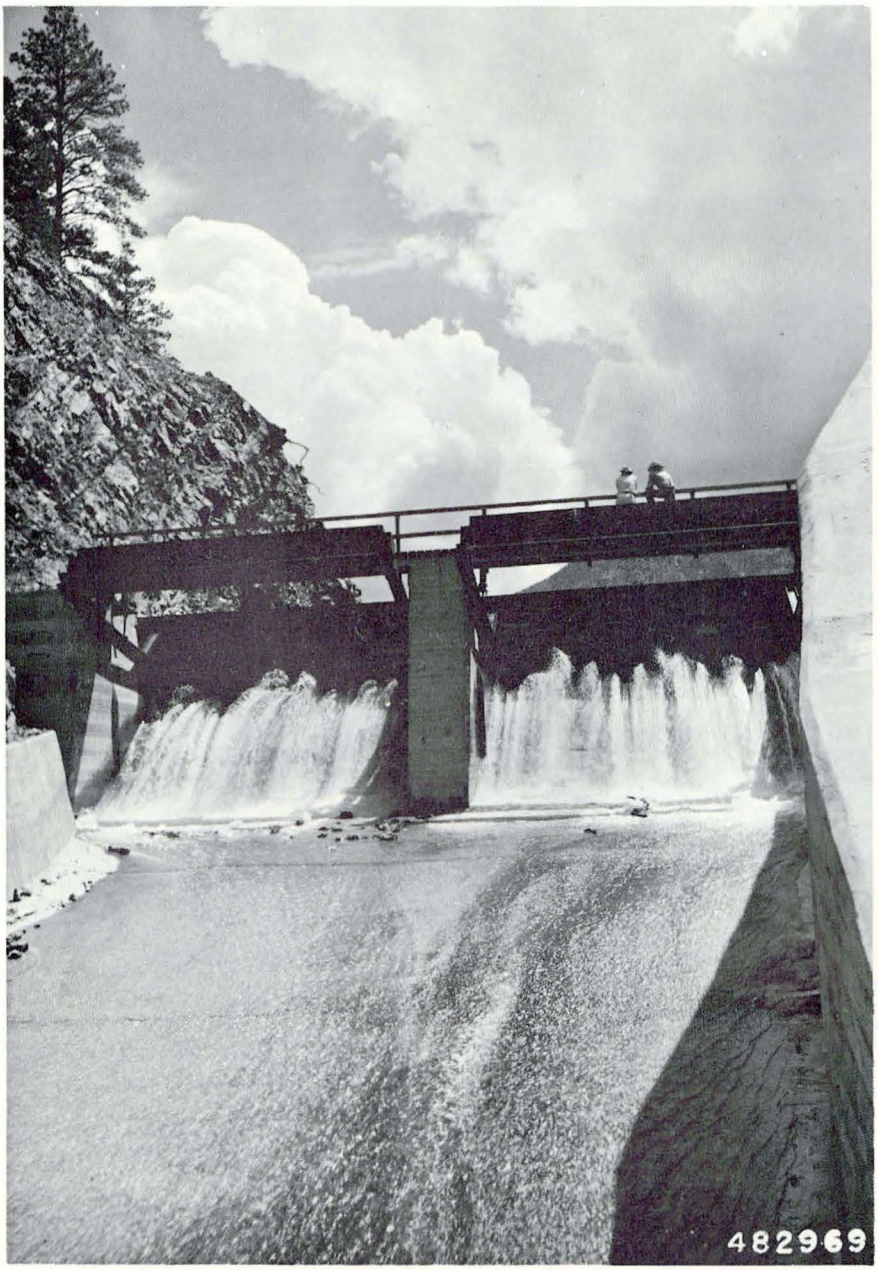


Picture taken October 1964

This reservoir is just upstream from two-mile Reservoir. Total capacity of this reservoir is 796 acre feet. It was constructed in 1943.

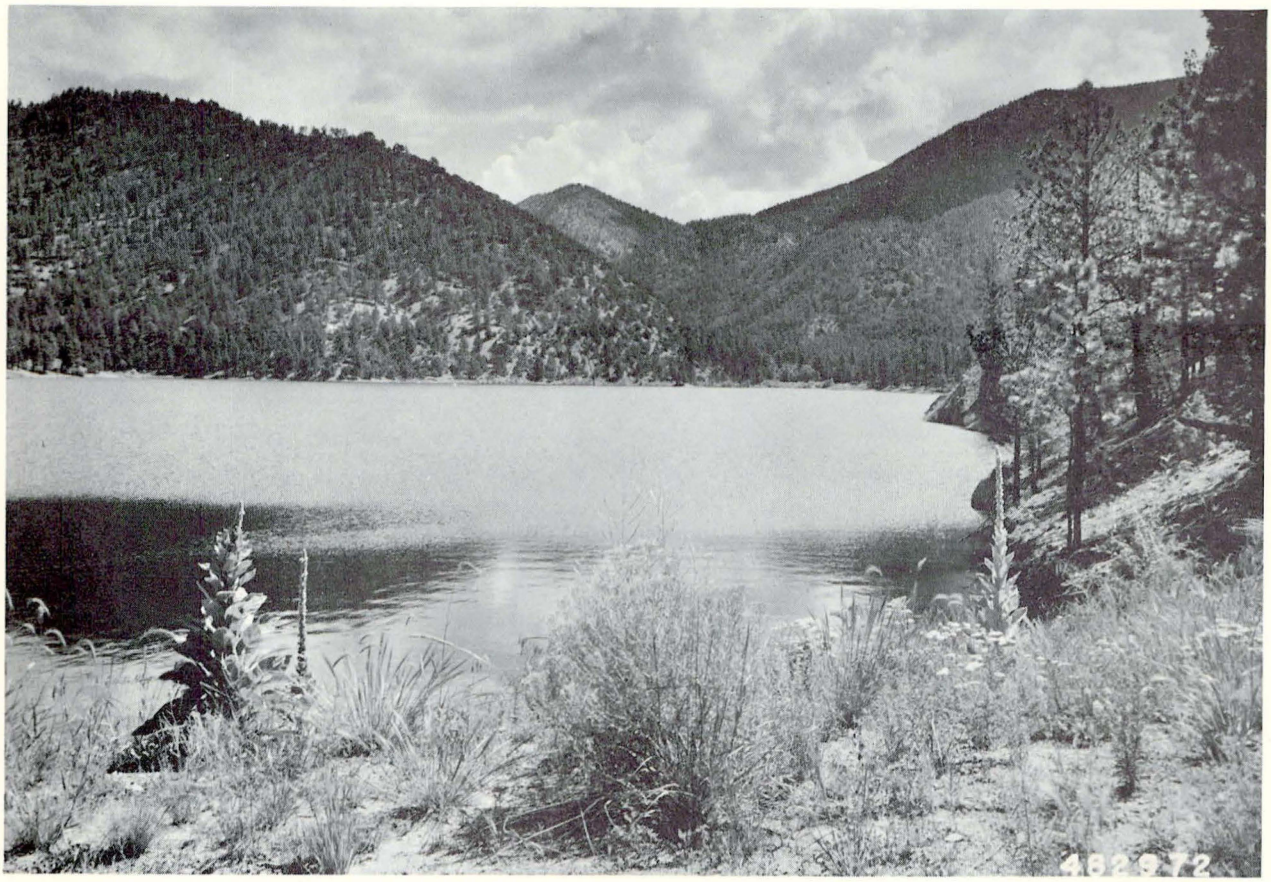
(3) U.S.G.S. stream gage 0.4 mile downstream from McClure Reservoir. See picture for WMU #7 which shows a picture of this stream gage. This gage was established at this location in 1947. Prior to that date it was located at two different locations. The earliest records were obtained from a stream gage located at the present side of Nichols Reservoir. These records date from April 1913 to November 1930. From November 1930 to October 1947 the gaging site was located 300 feet downstream from McClure dam. From October 1947 to the present the stream gage was located 0.4 mile downstream from McClure Reservoir.

(4) McClure Reservoir



Picture taken July 1957

Spillway of McClure Reservoir. This was an extremely wet year; this spillway normally does not carry any water.



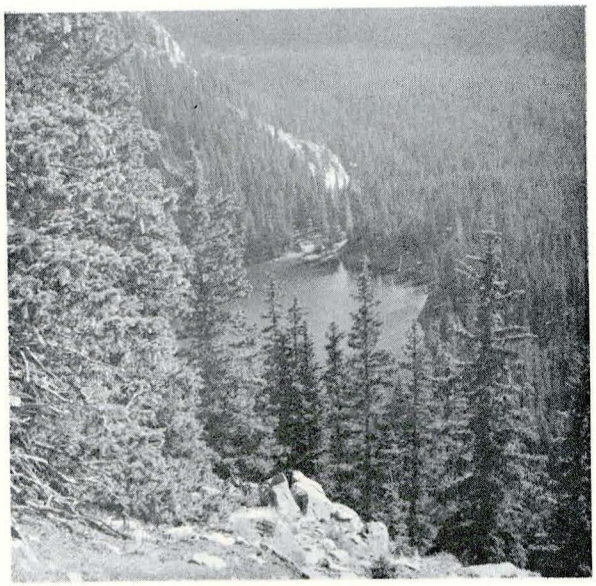
Picture taken July 1957

This reservoir is the largest one of the three. It has 80 surface acres and 2908 acre-feet of total capacity. The dam was first built in 1926, increased in 1935, and increased again to its present capacity in 1947.

(5) Two Parahall flumes which are owned and operated by the Public Service Company. One flume carries the normal flow and the second carries the flood flows.

(6) The site of the Old Elk Cabin. The Public Service Company has a storage gage located here. They read this gage twice each year. This non-recording rain gage can be seen in the lower left hand corner of the picture of WMU 4.

(7) Santa Fe Lake



Picture taken October 1964

This small lake is located near the top of the watershed just under Lake Peak. During the dry years prior to 1947, water was pumped from Santa Fe Lake to augment the natural stream flow. The Public Service Company maintains a non-recording rain gage one-fourth mile below Santa Fe Lake.

(8) This is the area of cornice development during the winter. See the picture for WMU #6. Winds from the north and west blow snow from the Santa Fe Ski Basin and deposit it on this steep rocky area.

FOOTNOTES

(1) Spiegel, Zane and Brewster Baldwin, Geology and Water Resources of the Santa Fe Area, New Mexico. Geological Survey Water - Supply Paper 1525. United States Printing Office, Washington: 1963. Page 171-172.

(2) Reynolds, S. E., Climatological Summary, New Mexico, Technical Report Number 6. 1956 P. 334

(3) Reynolds, S. E., Climatological Summary, New Mexico, Technical Report Number 6. 1956 P. 317

(4) Spiegel, Zane and Brewster Baldwin, Geology and Water Resources of the Santa Fe Area, New Mexico, Geological Survey Water - Supply Paper 1525. United States Printing Office, Washington: 1963. P. 146 and 150.

(5) Hardaway, George D. and J. Robert Thompson A Study of Water Yield from the Santa Fe River Watershed, Rocky Mountain Forest and Range Experiment Station, Station Paper No. 70. August 1962. Pp. 12-13

(6) Spiegal, Zane and Brewster Baldwin, Geology and Water Resources of the Santa Fe Area, New Mexico. Geological Survey Water - Supply Paper 1525. United States Printing Office, Washington: 1963 P. 156

9-179
(October 1952)
FLOOD DATA

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File .....

Flood data for **Santa Fe River**

Drainage area ..... square miles. Period of record .....

Flood data for momentary peak discharges greater than ..... cfs.

WATER YEAR	One Day DATE Mean cfs	GAGE HEIGHT (Feet)	DISCHARGE		ANNUAL FLOODS		PARTIAL DURATION SERIES		REMARKS
			~~Peak~~ AF	Ratio to $Q_{2.33}$	Order (M)	Recurrence Interval (Years)	Order (M)	Recurrence Interval (Years)	
1914	44		87.12		8	2.25			
15	124		245.52		3	4.66			
16	91		180.18		6	2.33			
17	24		47.52		11	1.27			
18	25		49.50		10	1.40			
19	160		316.80		2	7.0			
1920	92		182.16		5	2.8			
21	240		475.20		1	14.0			
22	24		47.52		12	1.16			
23	36		71.28		9	1.55			
24	55		108.90		7	2.0			
1925	72		14.25		13	1.08			
26	98		194.04		4	3.5			
	3 Days								
1914	41.3		245.32		8	2.25			
15	116.0		689.04		3	4.66			
16	88.0		522.72		5	2.8			
17	21.3		126.52		12	1.16			
18	24.7		146.72		10	1.40			
19	150.0		891.00		2	7.0			
1920	82.7		491.23		6	2.33			
21	214.0		1271.16		1	14			
22	24.0		142.56		11	1.27			
23	33.3		197.81		9	1.55			
24	54.7		324.92		7	2.0			
1925	7.2		42.77		13	1.08			
26	92.7		550.64		4	3.5			

Graphical mean annual flood ($Q_{2.33}$) ..... cfs for period .....

Sheet ..... of ..... Listed by ..... Date ..... Checked by ..... Date .....

U. S. GOVERNMENT PRINTING OFFICE 16---57384-2

GPO 841899

9-179
(October 1952)
FLOOD DATA

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File .....

Flood data for **Santa Fe River**
Drainage area ..... square miles. Period of record .....
Flood data for momentary peak discharges greater than ..... cfs.

WATER YEAR	7 Days DATE Mean cfs	GAGE HEIGHT (Feet)	DISCHARGE Af	DISCHARGE Ratio to $Q_{1.33}$	ANNUAL FLOODS Order (M)	ANNUAL FLOODS Recurrence Interval (Years)	PARTIAL DURATION SERIES Order (M)	PARTIAL DURATION SERIES Recurrence Interval (Years)	REMARKS
1914	39.3		544.70		8	2.25			
15	107.0		1483.02		3	4.66			
16	81.4		1128.20		5	2.8			
17	16.9		234.23		12	1.16			
18	22.6		313.24		11	1.27			
19	136.0		1884.96		2	7.0			
1920	74.1		1027.03		6	2.33			
21	170.0		2356.20		1	14.0			
22	22.9		317.39		10	1.40			
23	31.1		431.05		9	1.55			
24	52.4		726.26		7	2.0			
1925	6.5		90.09		13	1.08			
26	90.3		1251.56		4	3.5			
	15 Days								
1914	34.3		1018.71		8	2.25			
15	91.8		2726.46		3	4.66			
16	71.3		2117.61		5	2.8			
17	13.4		397.98		12	1.16			
18	29.9		888.03		10	1.40			
19	109.0		3237.30		2	7.0			
1920	56.5		1678.05		6	2.33			
21	120.0		3564.00		1	14			
22	22.1		656.37		11	1.27			
23	30.9		917.73		9	1.55			
24	48.3		1434.51		7	2.0			
1925	6.3		187.11		13	1.08			
26	81.5		2420.55		4	3.5			

Graphical mean annual flood ($Q_{2.33}$) ..... cfs for period .....

Sheet ..... of ..... Listed by ..... Date ..... Checked by ..... Date .....

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FLOOD DATA

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
WATER RESOURCES DIVISION

File .....

Flood data for **Santa Fe River**
Drainage area ..... square miles. Period of record .....
Flood data for momentary peak discharges greater than ..... cfs.

WATER YEAR	30 Days DATE Mean cfs	GAGE HEIGHT (Feet)	DISCHARGE		ANNUAL FLOODS		PARTIAL DURATION SERIES		REMARKS
			~~CFS~~ Af	RATIO TO $Q_{2.33}$	ORDER (M)	RECURRENCE INTERVAL (Years)	ORDER (M)	RECURRENCE INTERVAL (Years)	
1914	32.5		1930.50		8	2.25			
15	70.8		4205.52		3	4.66			
16	59.1		3510.54		5	2.8			
17	12.3		730.62		12	1.16			
18	21.2		1259.28		10	1.40			
19	87.2		5179.68		2	7.0			
1920	45.6		2708.64		6	2.33			
21	92.5		5494.50		1	14.0			
22	19.1		1134.54		11	1.27			
23	28.5		1692.90		9	1.55			
24	43.2		2566.08		7	2.0			
1925	5.9		350.46		13	1.08			
26	69.5		4128.30		4	3.55			

Graphical mean annual flood ($Q_{2.33}$) ..... cfs for period .....

Sheet ..... of ..... Listed by ..... Date ..... Checked by ..... Date .....

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GPO 841899

Appendix III

Year	Water Content on April 1			Runoff (April 1 - July 1)	
	Big Tesuque	Aspen Grove	Average	Acre-Feet	Area-Inches
			5.8		8.3
1943	5.3	3.0	4.2	2283	2.4
1944	8.6	5.6	7.1	3348	3.5
1945	10.2	7.3	8.8	4600	4.8
1946	3.1	1.4	2.2	1080	1.1
1947	0.7	0.7	0.7	1658	1.7
1948	10.7	7.3	9.0	3951	4.1
1949	5.2	1.8	3.5	4602	4.8
1950	0.6	0.6	0.6	529	0.6
1951	0.3	0.0	0.2	553	0.6
1952	7.7	4.3	6.0	3813	4.0
1953	1.3	1.7	1.5	1255	1.3
1954	3.4	1.8	2.6	1231	1.3
1955	0.3	0.6	0.4	1105	1.1
1956	0.0	0.0	0.0	410	0.4
1957	5.8	4.3	5.0	3630	3.8

BIG TESUQUE SNOW COURSE DATA

	Water Content		Runoff		
	X	X^2	Y	XY	Y^2
1943	5.3	28.09	2.4	12.72	5.76
1944	8.6	73.96	3.5	30.10	12.25
1945	10.6	112.36	4.8	50.88	23.04
1946	3.1	9.61	1.1	3.41	1.21
1947	0.7	.49	1.7	1.19	2.89
1948	10.7	114.49	4.1	43.87	16.81
1949	5.2	27.04	4.8	24.96	23.04
1950	0.6	.36	0.6	.36	.36
1951	0.3	.09	0.6	.18	.36
1952	7.7	59.29	4.0	30.80	16.00
1953	1.3	1.69	1.3	1.69	1.69
1954	3.4	11.56	1.3	4.42	1.69
1955	0.3	.09	1.1	.33	1.21
1956	0.0	.00	0.4	.00	.16
1957	5.8	33.64	3.8	22.04	14.44
	63.6	472.76	35.5	226.95	120.91

$(\Sigma X)^2 = 4044.96$
$(\Sigma Y)^2 = 1260.25$
$(\Sigma X)(\Sigma Y) = 2257.80$

$\bar{X} = 4.24$
$\bar{Y} = 2.37$

$\Sigma Y = Na + b\Sigma X$
$35.5 = 15a + 63.6b$

multiply by $\frac{63.6}{15} = 4.24$

$\Sigma XY = a\Sigma X + b\Sigma X^2$
$226.95 = 63.6a + 472.76b$

$226.95 = 63.6a + 472.76b$
$150.52 = 63.6a + 269.92b$
$76.43 = 202.84b$

$b = .38$

$35.5 = 15a + 63.6\ (.38)$
$35.5 = 15a + 24.2$
$11.3 = 15a$
$a = .75$

$Y = .75 + .38X$

$$\Sigma x^2 = \Sigma X^2 - \frac{(\Sigma X)^2}{N}$$

$$= 472.76 - \frac{4044.96}{15}$$

$$= 472.76 - 269.66 = 203.10$$

$$\Sigma y^2 = \Sigma Y^2 - \frac{(\Sigma Y)^2}{N}$$

$$= 120.91 - \frac{1260.25}{15}$$

$$= 120.91 - 84.02 = 36.89$$

$$\Sigma xy = \Sigma XY - \frac{(\Sigma X)(\Sigma Y)}{N}$$

$$= 226.95 - \frac{2257.80}{15}$$

$$= 226.95 - 150.52 = 76.43$$

$$r = \frac{Sxy}{\sqrt{(Sx^2)(Sy^2)}}$$

$$r = \frac{76.43}{\sqrt{(203.10)(36.89)}} = \frac{76.43}{\sqrt{7492.36}}$$

$$r = \frac{76.43}{86.56} = .88$$

$Y = a + bx$

$Y = .75 + .38x$

$\Sigma xy = 76.43$

$\Sigma x^2 = 203.10$

$\Sigma y^2 = 36.89$

$$\Sigma dy.x^2 = \Sigma y^2 - \frac{(\Sigma xy)^2}{\Sigma x^2}$$

$$36.89 - \frac{(76.43)^2}{203.10}$$

$$36.89 - \frac{5841.54}{203.10}$$

$$36.89 - 28.76 = 8.13$$

$$Sy.x^2 = \Sigma dy.x^2 / n-2$$

$$8.13 \;/\; 15-2$$

$$8.13/13 = .63$$

$$Sy.x = \sqrt{Sy.x^2} = \sqrt{.63} = .8$$

$t_{.05}$ at N-2 degrees of freedom = 2.160

X = 1, 3, 5, 7, 9, 11

$$SY^2 = t_{.05}\ Sy.x \sqrt{1 + \frac{1}{n} + \frac{(X - \bar{x})^2}{\Sigma x^2}}$$

$$SY^2 = 2.160 \cdot .8 \cdot \sqrt{1 + \frac{1}{15} + \frac{(X-4.24)^2}{203.10}}$$

$$SY_1^2 = 1.728 \sqrt{1.067 + \frac{(1-4.24)^2}{203.10}} = \pm 1.83$$

$$SY_3^2 = 1.728 \sqrt{1.067 + \frac{(3-4.24)^2}{203.10}} = \pm 1.79$$

$$SY_4^2 = 1.728 \sqrt{1.067 + \frac{(4-4.24)^2}{203.10}} = \pm 1.785$$

$$SY_5^2 = 1.728 \sqrt{1.067 + \frac{(5-4.24)^2}{203.10}} = \pm 1.79$$

$$SY_7^2 = 1.728 \sqrt{1.067 + \frac{(7-4.24)^2}{203.10}} = \pm 1.82$$

$$SY_9^2 = 1.728 \sqrt{1.067 + \frac{(9-4.24)^2}{203.10}} = \pm 1.88$$

$$SY_{11}^2 = 1.728 \sqrt{1.067 + \frac{(11-4.24)^2}{203.10}} = \pm 1.96$$

APPENDIX IV

Santa Fe DIVISION Water Department YEAR

Thousand Gallons Water Sold

		JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	TOTAL
Metered Sales Residential	ACTUAL LAST YEAR	38,784	34,128	33,238	56,915	96,668	116,072	129,473	110,663	85,669	73,259	56,998	50,477	882,544
	BUDGET THIS YEAR	40,515	35,650	34,720	59,450	100,380	121,245	135,250	115,810	89,490	60,050	54,390	42,450	890,000
	ACTUAL THIS YEAR	37662	36503	37577										
	CUMULATIVE BUDGET		76,165	110,885	170,335	271,315	392,560	527,810	643,620	733,110	793,160	847,550	890,000	
	CUMULATIVE ACTUAL	37662	74165	111,742										
Metered Sales Commercial	ACTUAL LAST YEAR	38,330	36,397	35,341	46,742	32,511	63,934	68,386	65,325	57,372	52,017	41,208	47,819	615,881
	BUDGET THIS YEAR	38,460	36,520	35,460	46,890	62,720	64,150	68,620	66,040	57,570	45,830	44,680	37,060	604,000
	ACTUAL THIS YEAR	25312	33622	37,620										
	CUMULATIVE BUDGET		74,980	110,440	157,330	220,050	284,200	352,820	418,860	476,430	522,260	566,940	604,000	
	CUMULATIVE ACTUAL	25312	58934	96,554										
Private Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Public Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Interdepartment Sales	ACTUAL LAST YEAR	24	19	14	116	91	285	92	89	156	79	86	66	1,117
	BUDGET THIS YEAR	80	80	80	80	80	90	90	80	85	85	85	85	1,000
	ACTUAL THIS YEAR	0	76	68										
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL	0	76	144										
	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Total	ACTUAL LAST YEAR	77,138	70,544	68,593	103,773	159,270	180,291	197,951	176,777	143,196	125,355	98,292	98,362	1,499,542
	BUDGET THIS YEAR	79,055	72,250	70,260	106,420	163,780	185,485	203,960	181,930	147,145	105,965	99,155	79,595	1,495,000
	ACTUAL THIS YEAR	62974	70201	72265										
	CUMULATIVE BUDGET		151,305	221,565	327,985	491,765	677,250	881,210	1,063,140	1,210,285	1,316,250	1,415,405	1,495,000	
	CUMULATIVE ACTUAL	62974	133175	208440										
Average Rate Per M Gallons	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													

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THOUSAND GALLONS WATER SOLD — SANTA FE DIVISION — WATER

		JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	TOTAL
Metered Sales Residential	ACTUAL LAST YEAR	30,548	27,610	28,186	37,712	68,989	99,307	87,721	93,164	101,479	50,447	35,091	34,24-	
	BUDGET THIS YEAR	31,200	28,900	29,500	39,500	72,100	104,000	91,600	97,400	106,100	84,400	53,300	33,300	
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET		60,800	90,300	129,800	201,900	305,900	397,500	494,900	601,000	685,400	738,700	772,500	
	CUMULATIVE ACTUAL													
Metered Sales Commercial	ACTUAL LAST YEAR	29,119	32,525	31,172	38,327	51,013	66,039	59,772	62,379	59,333	56,167	43,225	34,330	
	BUDGET THIS YEAR	29,700	33,100	31,800	39,100	52,000	67,300	60,900	63,500	61,000	53,400	42,700	35,500	
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET		62,800	94,600	133,700	185,700	253,000	313,900	377,400	438,400	491,800	534,500	570,000	
	CUMULATIVE ACTUAL													
Private Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR									(82)				
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Public Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Inter - Dept. Sales	ACTUAL LAST YEAR	1,185	758	910	1,147	1,359	1,973	1,703	3,289	2,587	538	17	369	15,334
	BUDGET THIS YEAR	830	540	640	810	960	1,390	1,200	2,320	1,820	2,050	570	370	14,000
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET		1,370	2,010	2,820	3,780	5,170	6,370	8,690	10,510	12,560	13,130	14,000	
	CUMULATIVE ACTUAL													
	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
TOTAL	ACTUAL LAST YEAR	60,853	60,894	60,268	77,186	121,361	167,319	149,196	158,732	163,899	117,152	79,333	59,543	1,285,735
	BUDGET THIS YEAR	62,430	62,540	61,940	79,410	125,060	172,690	153,700	163,220	168,920	139,850	96,570	70,170	1,356,500
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET		124,970	186,910	266,320	391,380	564,070	717,700	880,990	1,049,910	1,189,760	1,286,330	1,356,500	
	CUMULATIVE ACTUAL													

FEB 20 1959/60

THOUSAND GALLONS WATER SOLD — SANTA FE DIVISION — WATER DEPARTMENT — YEAR 1959/60

		JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	TOTAL
Metered Sales Residential	ACTUAL LAST YEAR	37,112	28,479	34,766	50,699	100,724	125,648	117,407	98,194	106,148	56,299	50,999	39,790	846,535
	BUDGET THIS YEAR	34,226	26,054	31,806	46,199	92,148	114,950	107,461	89,833	97,160	60,563	47,280	31,340	779,000
	ACTUAL THIS YEAR	28784	24128	23258	36,915	96668	136772	129413	[illegible]	[illegible]	18257	15918	12477	
	CUMULATIVE BUDGET	34,226	60,280	92,086	138,285	230,433	345,383	452,844	542,677	639,837	700,400	747,680	779,000	
	CUMULATIVE ACTUAL	28784	52912	76170	113085	209753	346525	[illegible]	[illegible]	[illegible]	115069	[illegible]	[illegible]	
Metered Sales Commercial	ACTUAL LAST YEAR	38,596	37,126	33,187	48,302	66,931	65,004	63,579	66,492	68,985	45,106	43,979	36,485	613,786
	BUDGET THIS YEAR	35,292	33,948	30,346	44,167	61,202	59,458	58,137	60,800	63,081	47,092	39,868	38,109	571,500
	ACTUAL THIS YEAR	28930	26877	23241	46,342	62511	69454	66306	[illegible]	51771	32617	41208	47815	
	CUMULATIVE BUDGET		69,240	99,586	143,753	204,955	264,413	322,550	383,350	446,431	493,523	533,391	571,500	
	CUMULATIVE ACTUAL	28930	55807	79048	125390	187901	257355	323661	[illegible]	474,837	507454	548662	596477	
Private Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Public Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Inter-Dept. Sales	ACTUAL LAST YEAR	411	19	117	213	103	146	81	71	76	7	72	11	1,327
	BUDGET THIS YEAR	214	198	106	194	94	133	74	65	69	103	114	136	1,500
	ACTUAL THIS YEAR	24	19	14	116	91	285	92	89	156	79	86	66	
	CUMULATIVE BUDGET		412	518	712	806	939	1,013	1,078	1,147	1,250	1,364	1,500	
	CUMULATIVE ACTUAL	24	43	57	173	264	549	641	730	886	965	1051	1117	
	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Total	ACTUAL LAST YEAR	76,419	65,624	68,070	99,214	167,758	190,818	181,067	164,757	175,210	101,412	95,050	76,289	1,461,658
	BUDGET THIS YEAR	69,732	60,200	62,258	90,560	153,444	174,541	165,672	150,698	160,310	107,758	81,242	75,585	1,352,000
	ACTUAL THIS YEAR	57138	50541	46,533	103,773	159270	180291	195951	[illegible]	[illegible]	125365	98292	98362	
	CUMULATIVE BUDGET		129,932	192,190	282,750	436,194	610,735	776,407	927,105	1,087,415	1,195,173	1,276,415	1,352,000	
	CUMULATIVE ACTUAL	57138	107679	154212	257985	417255	597546	[illegible]	[illegible]	[illegible]	1302888	[illegible]	[illegible]	
	ACTUAL LAST YEAR													

FORM BW 2-7/60

THOUSAND GALLONS WATER SOLD — Santa Fe DIVISION — Water Department — YEAR 1962

		JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	TOTAL
Metered Sales Residential	ACTUAL LAST YEAR	32,608	30,384	31,076	36,832	79,269	109,210	102,869	100,573	65,350	58,743	40,098	35,087	722,599
	BUDGET THIS YEAR	33,800	31,600	32,300	38,300	82,400	113,500	106,900	104,500	68,000	60,300	36,300	33,500	741,000
	ACTUAL THIS YEAR	27412	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible
	CUMULATIVE BUDGET		65,400	97,700	136,000	218,400	331,900	438,800	542,900	610,900	671,200	707,500	741,000	
	CUMULATIVE ACTUAL		illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	
Metered Sales Commercial	ACTUAL LAST YEAR	37,778	35,607	21,831	38,510	52,077	51,914	55,818	58,754	55,819	44,907	37,962	36,310	526,283
	BUDGET THIS YEAR	39,300	37,000	22,700	40,000	54,100	54,000	57,600	61,100	58,000	52,700	40,500	33,000	550,000
	ACTUAL THIS YEAR	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible
	CUMULATIVE BUDGET		76,300	99,000	139,000	193,100	247,100	304,700	365,800	423,800	476,500	517,000	550,000	
	CUMULATIVE ACTUAL		illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	
Private Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Public Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Inter-Dept. Sales	ACTUAL LAST YEAR	464	169	1,023	1,025	301	339	810	230	159	429	569	338	5,856
	BUDGET THIS YEAR	75	75	75	85	85	110	175	175	175	110	75	75	1,290
	ACTUAL THIS YEAR	411	19	119	illegible	illegible	illegible	illegible	illegible	illegible	7	76	11	1367
	CUMULATIVE BUDGET		150	225	310	395	505	680	850	1,030	1,140	1,215	1,290	
	CUMULATIVE ACTUAL		illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	
	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
TOTAL	ACTUAL LAST YEAR	70,850	66,160	53,930	76,367	131,647	161,463	158,775	159,557	119,328	104,079	78,629	72,735	1,255,438
	BUDGET THIS YEAR	73,175	68,675	55,075	78,385	136,585	167,610	164,275	165,775	126,175	113,110	76,875	66,575	1,292,290
	ACTUAL THIS YEAR	26419	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible
	CUMULATIVE BUDGET		141,850	196,925	275,310	411,895	579,505	743,780	909,555	1,035,730	1,148,840	1,225,715	1,292,290	
	CUMULATIVE ACTUAL		illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	illegible	
	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													

624,000

		JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUGUS	SEPT.	OCT.	NOV.	DEC.	
Metered Sales Residential	ACTUAL LAST YEAR	20,250	26,300	33,025	45,417	59,324	74,508	94,700	94,540	76,413	73,351	46,405	28,195	601,875
	BUDGET THIS YEAR	29,700	26,700	33,000	45,500	59,600	74,400	94,000	94,400	76,900	46,200	35,500	35,300	655,600
	ACTUAL THIS YEAR	20,877	27,415	32,118	46,067	59,361	77,711	98,144	101,476					
	CUMULATIVE BUDGET		56,400	89,400	134,900	194,500	268,900	363,300	457,700	534,600	580,800	616,300	652,600	
	CUMULATIVE ACTUAL		48,292	80,410	126,477	185,838	263,549	361,693	463,169	564,645	638,996			
Metered Sales Commercial	ACTUAL LAST YEAR	30,850	34,887	38,806	41,458	46,360	54,031	62,769	57,503	55,325	51,014	40,762	34,173	584,809
	BUDGET THIS YEAR	30,800	34,900	38,700	41,500	46,900	54,100	62,800	58,000	55,400	38,500	35,900	31,500	532,600
	ACTUAL THIS YEAR	29,117	34,824	37,772	41,[illegible]	47,[illegible]	61,[illegible]	59,[illegible]	63,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	CUMULATIVE BUDGET		65,700	100,400	141,900	188,800	242,900	305,700	363,700	419,100	457,600	494,500	532,000	
	CUMULATIVE ACTUAL		63,941	97,713	139,184	186,157	247,[illegible]	307,[illegible]	370,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
Private Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Public Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Inter-Dept. Sales	ACTUAL LAST YEAR	4,492	4,368	3,866	4,198	3,826	2,314	717	792	2,303	3,281	904	1,[illegible]	32,[illegible]
	BUDGET THIS YEAR	1,824	1,368	1,482	1,140	1,492	4,807	5,545		3,011	1,958	888	1,235	24,111
	ACTUAL THIS YEAR	1,185	726	910	4,147	1,389	1,973	703	2,267	2,[illegible]	[illegible]	[illegible]	1,[illegible]	[illegible]
	CUMULATIVE BUDGET		3,192	4,674	5,814	7,306	12,113	17,661		20,672	22,230	22,876	24,111	
	CUMULATIVE ACTUAL		1,911	2,[illegible]	6,[illegible]	8,[illegible]	7,[illegible]	9,[illegible]	[illegible]	1,[illegible]	[illegible]	[illegible]	[illegible]	
	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
TOTAL	ACTUAL LAST YEAR	64,608	65,755	71,497	91,083	110,010	131,253	158,195	153,243	134,025	127,658	88,052	63,[illegible]	1,219,[illegible]
	BUDGET THIS YEAR	62,324	62,968	69,182	88,140	107,992	133,307	162,748	152,400	135,311	86,258	76,446	68,035	1,211,111
	ACTUAL THIS YEAR	51,179	62,965	70,800	91,[illegible]	108,[illegible]	141,[illegible]	157,[illegible]	167,[illegible]	165,[illegible]	117,[illegible]	77,[illegible]	64,[illegible]	1,[illegible]
	CUMULATIVE BUDGET		125,292	194,474	282,614	390,606	523,913	686,661	839,061	974,372	1,060,630	1,137,076	1,205,111	
	CUMULATIVE ACTUAL		114,143	184,943	276,[illegible]	384,[illegible]	525,[illegible]	683,[illegible]	850,[illegible]	1,015,[illegible]	1,133,[illegible]	1,210,[illegible]	1,275,[illegible]	
	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													

10-26-59

1460 Ref for Budget

Form Bu 2

THOUSAND GALLONS WATER SOLD — SANTA FE DIVISION — WATER — YEAR 19_ — Sheet No.

		JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPT.	OCT.	NOV.	DEC.	TOTAL
Metered Sales Residential	ACTUAL LAST YEAR	28,576	24,390	24,413	26,971	42,314	89,873	101,673	94,537	56,057	41,330	35,356	31,619	597,614
	BUDGET THIS YEAR	29,100	25,000	25,000	27,500	43,100	91,600	103,700	96,400	57,200	59,700	30,500	26,200	615,000
	ACTUAL THIS YEAR	29,244	24,300	28,025	47,417	87,324	94,902	94,709	94,918	56,44[illegible]	29,24[illegible]	46,40[illegible]	26,195	
	CUMULATIVE BUDGET	29,100	54,100	79,100	106,600	149,700	241,300	345,000	441,400	498,600	558,300	588,800	615,000	
675,000 14% Increase 1959	CUMULATIVE ACTUAL	29,244	53,544	82,571	129,988	173,312	268,240	363,949	458,867	515,311	574,555	620,960	647,155	54.1%
Metered Sales Commercial	ACTUAL LAST YEAR	31,263	29,992	30,769	34,328	42,676	57,068	66,390	56,820	50,750	36,708	35,261	35,964	507,185
	BUDGET THIS YEAR	31,600	29,400	31,300	35,600	43,600	58,100	67,600	57,900	51,700	52,800	43,300	32,100	535,000
	ACTUAL THIS YEAR	30,85[illegible]	34,657	34,[illegible]	41,46[illegible]	49,8[illegible]	64,631	62,769	57,913	55,3[illegible]	51,0[illegible]	40,782	34,173	
545,000	CUMULATIVE BUDGET	31,600	61,000	92,300	127,900	171,500	229,600	297,200	355,100	406,800	459,600	502,900	535,000	
.5% increase 1959	CUMULATIVE ACTUAL	30,85[illegible]	65,731	100,[illegible]	141,[illegible]	191,[illegible]	256,[illegible]	319,[illegible]	377,[illegible]	433,[illegible]	484,[illegible]	525,[illegible]	559,[illegible]	4.1%
1,224,000,000	ACTUAL LAST YEAR													
Private Fire Protection	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Public Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Inter-Dept. Sales	ACTUAL LAST YEAR	6,062	5,243	5,569	6,676	8,188	10,240	5,600	5,417	4,672	843	4,212	4,739	67,[illegible]
	BUDGET THIS YEAR	4,700	4,000	4,300	5,200	6,400	8,000	4,400	4,200	3,600	5,100	5,600	4,500	60,[illegible]
	ACTUAL THIS YEAR	4,56[illegible]	4,[illegible]	8,[illegible]	4,[illegible]	3,[illegible]	2,[illegible]	71[illegible]	77[illegible]	3,[illegible]	5,[illegible]	9,[illegible]	1,[illegible]	
	CUMULATIVE BUDGET	4,700	8,700	13,000	18,200	24,600	32,600	37,000	41,200	44,800	49,900	55,500	60,000	
	CUMULATIVE ACTUAL	4,56[illegible]	9,[illegible]	13,[illegible]	17,[illegible]	20,[illegible]	23,[illegible]	24,[illegible]	24,[illegible]	29,[illegible]	34,[illegible]	34,[illegible]	36,[illegible]	[illegible]
	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Total	ACTUAL LAST YEAR	65,706	58,515	60,748	68,575	93,178	157,181	173,663	156,774	111,489	79,381	74,809	72,242	1,121,[illegible]
	BUDGET THIS YEAR	65,400	58,400	60,600	68,300	93,100	157,700	175,700	158,500	112,500	117,600	79,400	62,800	1,[illegible]
	ACTUAL THIS YEAR	64,[illegible]	65,[illegible]	84,[illegible]	91,[illegible]	119,[illegible]	159,[illegible]	158,[illegible]	153,[illegible]	115,[illegible]	87,[illegible]	91,[illegible]	67,[illegible]	
	CUMULATIVE BUDGET	65,400	123,800	184,400	252,700	345,800	503,500	679,200	837,700	950,200	1,067,800	1,147,200	1,210,000	
	CUMULATIVE ACTUAL	64,[illegible]	129,[illegible]	213,[illegible]	304,[illegible]	423,[illegible]	583,[illegible]	741,[illegible]	895,[illegible]	1,010,[illegible]	1,097,[illegible]	1,189,[illegible]	1,257,[illegible]	[illegible]
	ACTUAL LAST YEAR													

THOUSAND GALLONS WATER SOLD — NTA — DIVISION — WATER — YEAR

		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	TOTAL
Metered Sales Residential	ACTUAL LAST YEAR	27,025	23,979	24,907	30,190	50,220	63,614	95,528	52,[illegible]	[illegible],279	56,437	[illegible],383	24,777	534,537
	BUDGET THIS YEAR	30,000	26,500	27,500	33,000	55,000	70,000	105,[illegible]	58,000	[illegible],000	[illegible],500	41,[illegible]	27,000	600,000
	ACTUAL THIS YEAR	28,576	24,[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	101,675	[illegible]	[illegible]				
	CUMULATIVE BUDGET	30,000	56,500	84,000	117,000	172,000	242,000	[illegible]	405,000	463,000	532,[illegible]	573,000	600,000	
	CUMULATIVE ACTUAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
Metered Sales Commercial	ACTUAL LAST YEAR	32,349	30,844	30,005	[illegible],158	43,622	48,511	[illegible],[illegible]	44,[illegible]	21,03[illegible]	40,[illegible]	39,5[illegible]	45,[illegible]	[illegible]25,010
	BUDGET THIS YEAR	35,000	33,500	32,500	37,000	47,000	52,500	62,[illegible]	48,000	55,[illegible]	56,[illegible]	41,[illegible]	38,[illegible]	525,000
	ACTUAL THIS YEAR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
	CUMULATIVE BUDGET	35,000	68,500	101,000	138,000	185,000	237,500	300,000	348,000	403,[illegible]	453,500	494,5[illegible]	525,000	
	CUMULATIVE ACTUAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	379,351				
Private Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Public Fire Protection	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Inter-Dept. Sales	ACTUAL LAST YEAR	6,782	6,573	5,850	6,565	6,235	6,553	7,241	7,151	7,397	5,[illegible]	5,727	6,111	77,943
	BUDGET THIS YEAR	6,800	6,700	6,000	6,700	6,400	6,700	7,400	7,300	7,500	7,100	8,000	6,400	83,000
	ACTUAL THIS YEAR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
	CUMULATIVE BUDGET	6,800	13,500	19,500	26,200	32,600	39,300	46,700	54,000	61,500	68,600	76,600	83,000	
	CUMULATIVE ACTUAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]				
	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													
	CUMULATIVE BUDGET													
	CUMULATIVE ACTUAL													
Total	ACTUAL LAST YEAR	66,156	61,396	60,762	70,913	100,077	118,678	160,485	103,919	114,917	103,248	70,091	76,848	1,107,490
	BUDGET THIS YEAR	71,800	66,700	66,000	76,700	108,400	129,200	17[illegible],900	113,300	126,000	121,100	90,000	63,900	1,208,000
	ACTUAL THIS YEAR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	173,663	[illegible]	111,769				
	CUMULATIVE BUDGET	71,800	138,500	204,500	281,200	389,600	518,800	693,700	807,000	933,000	1,054,100	1,144,100	1,208,000	
	CUMULATIVE ACTUAL		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	677,[illegible]	[illegible]	[illegible]				
	ACTUAL LAST YEAR													
	BUDGET THIS YEAR													
	ACTUAL THIS YEAR													

SANTA FE MUNICIPAL WATERSHED - AERIAL PHOTOS

Quad 109

Line 6
- EEB 2-174
- 2-175
- 2-176
- 2-177
- 2-178

Line 5
- EEB 8-58
- 8-59

Quad 133

Line 6
- EEB 2-173

Line 5
- EEB 8-60
- 8-61
- 8-62
- EEB 1-185
- EEB 8-63
- EEB 1-186

Line 4
- EEB 1-125
- 1-126
- 1-127
- 1-128
- 1-129

Line 3
- EEB 1-99
- 1-100
- 1-101
- 1-102

Line 2
- EEB 2-80
- 2-79
- 2-78
- 2-77

Bibliography

_____ Precipitation Data from Storage-Gage Stations, April 1960. Pp. 29-33 and 46.

Hardaway, George D. and J. Robert Thompson, A Study of Water Yield from the Santa Fe River Watershed. Station Paper No. 70, August 1962, 18 pages.

Hendricks, E.L. Compilation of Records of Surface Waters of the United States October 1950 to September 1960 - Part 8. Western Gulf of Mexico Basins. Geological Survey Water-Supply Paper 1732, 1964. P. 410.

Hershfield, David M., Rainfall Frequency Atlas of the United States - Technical Paper No. 40. U. S. Department of Commerce, Weather Bureau, Washington D.C. January 1963, 61 pages.

Long, A. R., Climatological Summary - Santa Fe 1850 to 1946 - 22 pages.

Reiland, L. J. and G.L. Haynes Jr., Flow Characteristics of New Mexico Streams. Flow Duration, High-Flow, and Low-Flow Tables for Selected Stations through Water Year 1959. 1963. Pp. 152-153

Reynolds, S.E., Climatological Summary, New Mexico. Precipitation 1849-1954. Technical Report No. 6, 1956. Pp. 334-337.

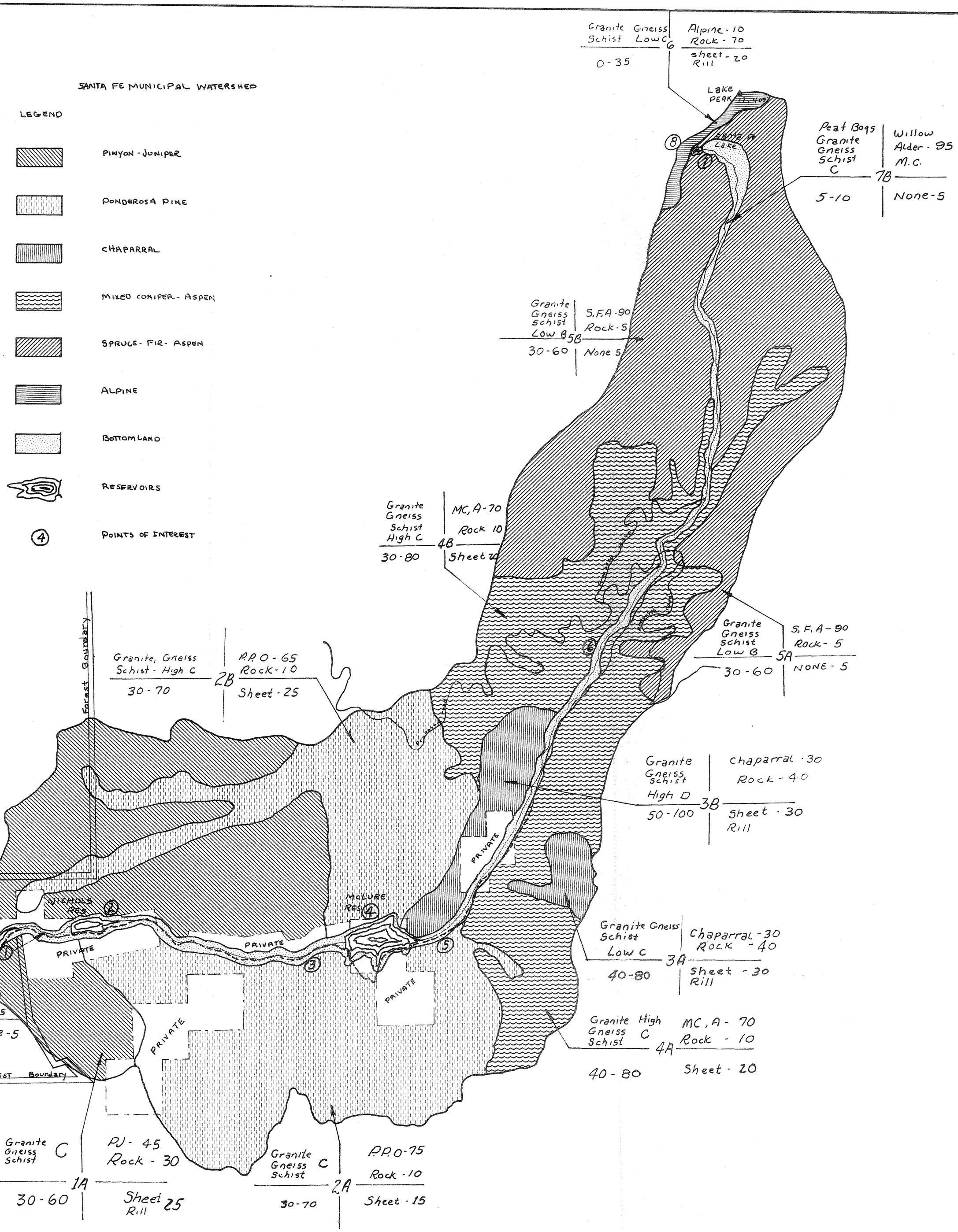
Spiegel, Zane and Brewster Baldwin, Geology and Water Resources of the Santa Fe Area, New Mexico. Geological Survey Water-Supply. Paper 1525. 1963.

Wells, J.V.B., Compilation of Records of Surface Waters of the United States through September 1950 - Part 8. Western Gulf of Mexico Basins. Geological Survey Water-Survey. Water-Supply Paper 1312. 1960. Pp. 442-445.

SANTA FE MUNICIPAL WATERSHED

LEGEND

- PINYON - JUNIPER
- PONDEROSA PINE
- CHAPARRAL
- MIXED CONIFER - ASPEN
- SPRUCE - FIR - ASPEN
- ALPINE
- BOTTOM LAND
- RESERVOIRS
- (4) POINTS OF INTEREST



SOIL MANAGEMENT AREA MAP
SANTA FE MUNICIPAL WATERSHED

SCALE 2" = 1 MILE

NAMBE-KATHERINE SOIL AREA

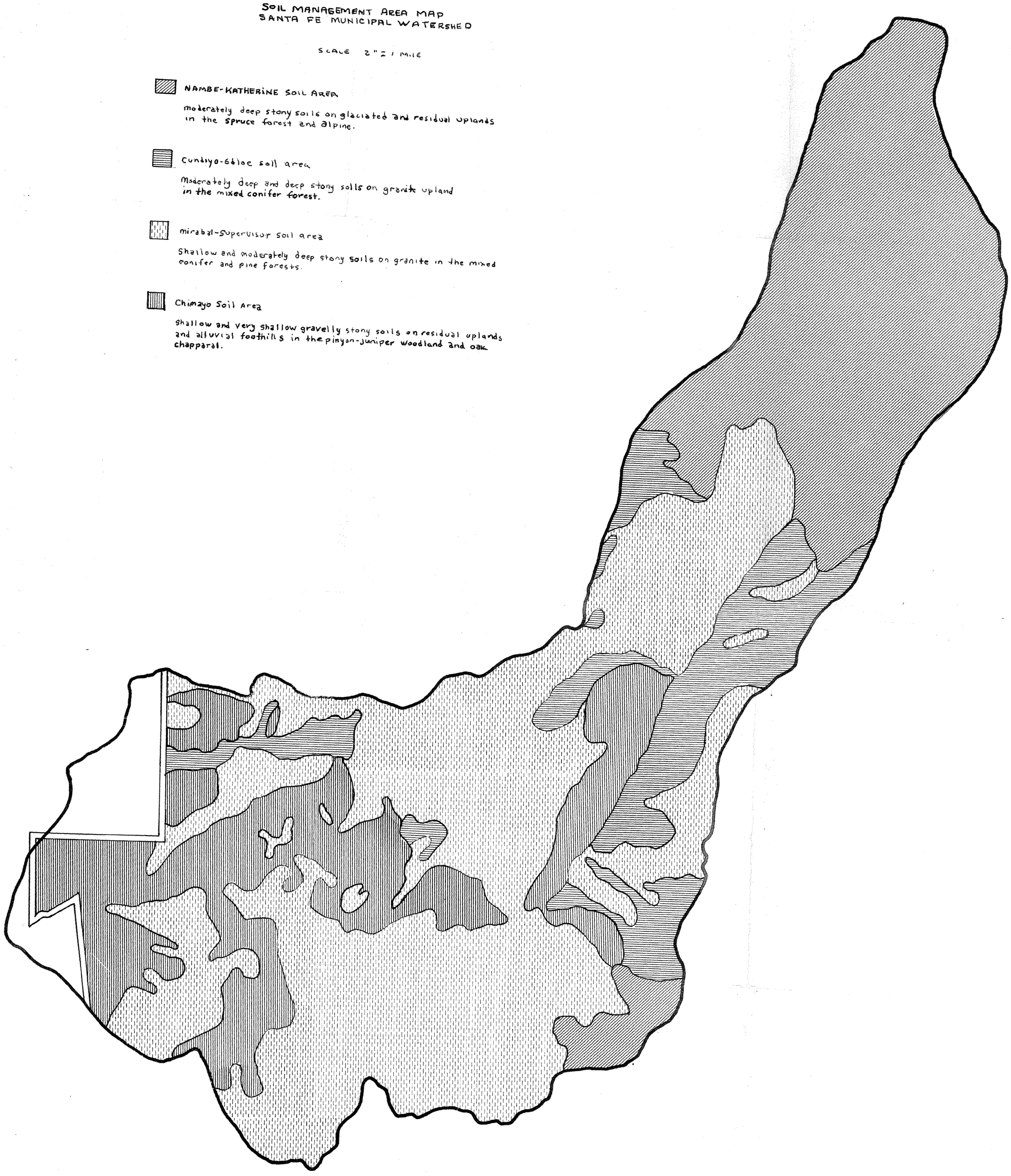
moderately deep stony soils on glaciated and residual uplands in the spruce forest and alpine.

Cundiyo-Gobloc soil area

Moderately deep and deep stony soils on granite upland in the mixed conifer forest.

Mirabal-Supervisor soil area

Shallow and moderately deep stony soils on granite in the mixed conifer and pine forests.

Chimayo Soil Area

Shallow and very shallow gravelly stony soils on residual uplands and alluvial foothills in the pinyon-juniper woodland and oak chapparal.